THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. I.—*On the Origination and Distribution of Species:—Introductory Essay to the Flora of Tasmania;* by Dr. JOSEPH D. HOOKER.*

§ 1. *Preliminary Remarks.*

THE Island of Tasmania does not contain a vegetation peculiar to itself, nor constitute an independent botanical region. Its plants are, with comparatively few exceptions, natives of extra-tropical Australia; and I have consequently found it necessary to study the vegetation of a great part of that vast continent, in order to determine satisfactorily the nature, distribution, and

* *To the Editors of the American Journal of Science, &c.*:—The sheets of this *Introductory Essay*, having been obligingly communicated to me in advance of the publication of the concluding part of the *Flora of Tasmania*, to which it belongs, I asked and have received the distinguished author's permission to reprint them, or a considerable portion of them, in your Journal, and now offer them for that purpose. This is in order that we may have before us, at the earliest date, an essay which cannot fail to attract the immediate and profound attention of scientific men; but which, if confined to the pages of the *Flora of Tasmania*, would be seen by very few American readers. To those who have intelligently observed the course of scientific investigation, and the tendency of speculation, it has for some time been manifest that a re-statement of the Lamarkian hypothesis is at hand. We have this, in an improved and truly scientific form, in the theories which, recently propounded by Mr. Darwin, followed by Mr. Wallace, are here so ably and altogether independently maintained. When these views are fully laid before them, the naturalists of this country will be able to take part in the interesting discussion which they will not fail to call forth.

To save room, a few paragraphs are omitted which do not directly bear upon the subject in hand. A. G.

affinities of the Tasmanian Flora. From the study of certain extratropical genera and species in their relation to those of Tasmania, I have been led to the far more comprehensive undertaking of arranging and classifying all the Australian plants accessible to me. This I commenced in the hope of being able thereby to extend our knowledge of the affinities of its Flora, and, if possible, to throw light on a very abstruse subject, viz. the origin of its vegetation, and the sources or causes of its peculiarity. This again has induced me to proceed with the inquiry into the oxigin and distribution of existing species; and, as I have already treated of these subjects in the Introduction to the New Zealand Flora, I now embrace the opportunity afforded me by a similar Introduction to the Tasmanian Flora, of revising the opinions I then entertained, and of again investigating the whole subject of the creation of species by variation, with the aid of the experience derived from my subsequent studies of the Floras of India and Australia in relation to one another and to those of neighboring countries, and of the recently published hypotheses of Mr. Darwin and Mr. Wallace. * * *

In the Introductory Essay to the New Zealand Flora, I advanced certain general propositions as to the origin of species, which I refrained from endorsing as articles of my own creed: amongst others was the still prevalent doctrine that these are, in the ordinary acceptation of the term, created as such, and are immutable. In the present Essay I shall advance the opposite hypothesis, that species are derivative and mutable; and this chiefly because, whatever opinions a naturalist may have adopted with regard to the origin and variation of species, every candid mind must admit that the facts and arguments upon which he has grounded his convictions require revision since the recent publication by the Linnean Society of the ingenious and original reasonings and theories of Mr. Darwin and Mr. Wallace.

Further, there must be many who, like myself, having hitherto refrained from expressing any positive opinion, now, after a careful consideration of these naturalists' theories, find the aspect of the question materially changed, and themselves freer to adopt such a theory as may best harmonize with the facts adduced by their own experience.

The Natural History of Australia seemed to me to be especially suited to test such a theory, on account of the comparative uniformity of its physical features being accompanied with a great variety in its Flora; of the differences in the vegetation of its several parts; and of the peculiarity both of its Fauna and Flora, as compared with those of other countries. I accordingly prepared a classified catalogue of all the Australian species in the Herbarium, with their ranges in longitude, latitude, and elevation, as far as I could ascertain them, and added what fur-

ther information I could obtain from books. At the same time I made a careful study of the affinities and distribution of all the Tasmanian species, and of all those Australian ones which I believed to be found in other countries. I also determined as accurately as I could the genera of the remainder, and especially of those belonging to genera which are found in other countries, and I distinguished the species from one another in those genera which had not been previously arranged. In this manner I have brought together evidence of nearly 8000 flowering plants having been collected or observed in Australia, of which I have seen and catalogued upwards of 7000. About two-thirds of these are ascertained specifically with tolerable accuracy, and the remainder are distinguished from one another, and referred to genera with less certainty, being either undescribed, or described under several names, whilst some are members of such variable groups that I was left in doubt how to dispose of them.

To many who occupy themselves with smaller and better worked botanical districts, such results as may be deduced from the skeleton Flora I have compiled for Australia may seem too crude and imperfect to form data from which to determine its relations. But it is not from a consideration of specific details that such problems as those of the relations of Floras and the origin and distribution of organic forms will ever be solved, though we must eventually look to these details for proofs of the solutions we propose. The limits of the majority of species are so undefinable that few naturalists are agreed upon them;* to a great extent they are matters of opinion, even amongst those persons who believe that species are original and immutable creations; and as our knowledge of the forms and allies of each increases, so do these differences of opinions; the progress of systematic science being, in short, obviously unfavorable to the view that most species are limitable by descriptions or characters, unless large allowances are made for variation. On the other hand, when dealing with genera, or other combinations of species, all that is required is that these be classified in natural groups; and that such groups are true exponents of affinities settled by Nature is abundantly capable of demonstration. It is to an investigation of the extent, relations, and proportions of these natural combinations of species, then, that we must look for the means of obtaining and expressing the features of a Flora; and if in this instance the exotic species are well ascertained, it matters little whether or not the endemic are in all cases accurately distinguished from one another. Further, in a Flora so large as that of Australia, if the species are limited and

* The most conspicuous evidence of this lies in the fact, that the number of known species of flowering plants is by some assumed to be under 80,000, and by others over 150,000.

estimated by one mind and eye, the errors made under each genus will so far counteract one another, that the mean results for the genera and orders will scarcely be affected. As it is, the method adopted has absorbed many weeks of labor during the last five years, and a much greater degree of accuracy could only have been obtained by a disproportionately greater outlay of time, whilst it would not have materially affected the general results.

With regard to my own views on the subjects of the variability of existing species and the fallacy of supposing we can ascertain anything through these alone of their ancestry or of originally created types, they are, in so far as they are liable to influence my estimate of the value of the facts collected for the analysis of the Australian Flora, unaltered from those which I maintained in the 'Flora of New Zealand.' On such theoretical questions, however, as the origin and ultimate permanence of species, they have been greatly influenced by the views and arguments of Mr. Darwin and Mr. Wallace above alluded to, which incline me to regard more favorably the hypothesis that it is to variation that we must look as the means which Nature has adopted for peopling the globe with those diverse existing forms which, when they tend to transmit their characters unchanged through many generations, are called species. Nevertheless I must repeat, what I have fully stated elsewhere, that these hypotheses should not influence our treatment of species, either as subjects of descriptive science, or as the means of investigating the phenomena of the succession of organic forms in time, or their dispersion and replacement in area, though they should lead us to more philosophical conceptions on these subjects, and stimulate us to seek for such combinations of their characters as may enable us to classify them better, and to trace their origin back to an epoch anterior to that of their present appearance and condition. In doing this, however, the believer in species being lineally related forms must employ the same methods of investigation and follow the same principles that guide the believer in their being actual creations, for the latter assumes that Nature has created species with mutual relations analogous to those which exist between the lineally-descended members of a family, and this is indeed the leading idea in all natural systems. On the other hand, there are so many checks to indiscriminate variation, so many inviolable laws that regulate the production of varieties, the time required to produce wide variations from any given specific type is so great, and the number of species and varieties known to propagate for indefinite periods a succession of absolutely identical members is so large, that all naturalists are agreed that for descriptive purposes species must be treated as if they were at their origin distinct,

and are destined so to remain. Hence the descriptive naturalist who believes all species to be derivative and mutable, only differs in practice from him who asserts the contrary, in expecting that the posterity of the organism he describes as species may, at some indefinitely distant period of time, require redescription.

I need hardly remark that the classificatory branch of Botany is the only one from which this subject can be approached; for a good system must be founded on a due appreciation of all the attributes of individual plants,—upon a balance of their morphological, physiological, and anatomical relations at all periods of their growth. Species are conventionally assumed to represent, with a great amount of uniformity, the lowest degree of such relationship; and the facts that individuals are more easily grouped into species limited by characters, than into varieties, or than species are into limitable genera or groups of higher value, and that the relationships of species are transmitted hereditarily in a very eminent degree, are the strongest appearances in favor of species being original creations, and genera, etc., arbitrarily limited groups of these.

The difference between varieties and species and genera in respect to definable limitation is however one of degree only, and if increased materials and observation confirm the doctrine which I have for many years labored to establish, that far more species are variable, and far fewer limitable, than has been supposed, that hypothesis will be proportionally strengthened which assumes species to be arbitrarily limited groups of varieties. With the view of ascertaining how far my own experience in classification will bear out such a conclusion, I shall now endeavor to review, without reference to my previous conclusions, the impressions which I have derived from the retrospect of twenty years' study of plants. During that time I have classified many large and small Floras, arctic, temperate and tropical, insular and continental: embracing areas so extensive and varied as to justify, to my apprehension, the assumption that the results derived from these would also be applicable to the whole vegetable kingdom. I shall arrange these results successively under three heads; viz., facts derived from a study of classification; secondly, from distribution; thirdly, from fossils; after which I shall examine the theories with which these facts should harmonize.

§ 2. *On the General Phenomena of Variation in the Vegetable Kingdom.*

1. All vegetable forms are more or less prone to vary as to their sensible properties, or (as it has been happily expressed in regard to all organisms), "they are in a state of unstable equilibrium."* No organ is exactly symmetrical, no two are exact

* Essays: Scientific, Political, and Speculative; by Herbert Spencer: p. 280.

counterparts, no two individuals are exactly alike, no two parts of the same individual exactly correspond, no two species have equal differences, and no two countries present all the varieties of a species common to both, nor are the species of any two countries alike in number and kind.

2. The rate at which plants vary is always slow, and the extent or degree of variation is graduated. Sports even in color are comparatively rare phenomena, and, as a general rule, the best-marked varieties occur on the confines of the geographical area which a species inhabits. Thus the scarlet Rhododendron (*R. arboreum*) of India inhabits all the Himalaya, the Khasia Mountains, the Peninsular Mountains, and Ceylon; and it is in the centre of its range (Sikkim and the Khasia) that these mean forms occur which by a graduated series unite into one variable species, the rough, rusty-leaved form of Ceylon, and the smooth, silvery-leaved form of the northwestern Himalaya. A white and a rose-colored sport of each variety is found growing with the scarlet in all these localities, but everywhere these sports are few in individuals. Also certain individuals flower earlier than others, and some occasionally twice a year, I believe in all localities.

3. I find that in every Flora all groups of species may be roughly classified into three large divisions: one in which most species are apparently unvarying; another in which most are conspicuously varying; and a third which consists of a mixture of both in more equal proportions. Of these the unvarying species appear so distinct from one another that most botanists agree as to their limits, and their offspring are at once referable by inspection to their parents; each presents several special characters, and it would require many intermediate forms to effect a graduated change from any one to another. The most varying species, on the contrary, so run into one another, that botanists are not agreed as to their limits, and often fail to refer the offspring with certainty to their parents, each being distinguished from one or more others by one or a few such trifling characters, that each group may be regarded as a continuous series of varieties, between the terms of which no hiatus exists suggesting the intercalation of any intermediate variety. The genera *Rubus*, *Rosa*, *Salix*, and *Saxifraga*, afford conspicuous examples of these unstable species; *Veronica*, *Campanula*, and *Lobelia*, of comparatively stable ones.

4. Of these natural groups of varying and unvarying species, some are large and some small; they are also variously distributed through the classes, orders, and genera of the Vegetable Kingdom; but, as a general rule, the varying species are relatively most numerous in those classes, orders, and genera which

are the simplest in structure.* Complexity of structure is generally accompanied with a greater tendency to permanence in form: thus Acotyledons, Monocotyledons, and Dicotyledons are an ascending series in complexity and in constancy of form. In Dicotyledons, *Salices*, *Urticeæ*, *Chenopodiaceæ*, and other orders with incomplete or absent floral envelops, vary on the whole more than *Leguminosæ*, *Lythraceæ*, *Myrtaceæ*, or *Rosaceæ*, yet members of these present, in all countries, groups of notoriously varying species, as *Eucalyptus* in Australia, *Rosa* in Europe, and *Lotus*, *Epilobium*, and *Rubus* in both Europe and Australia. Again, even genera are divided: of the last named, most or all of the species are variable; of others, as *Epacris*, *Acacia*, and the majority of such as contain upwards of six or eight species, a larger or smaller proportion only are variable. But the prominent fact is, that this element of mutability pervades the whole vegetable kingdom; no class nor order nor genus of more than a few species claims absolute exemption, whilst the grand total of unstable forms generally assumed to be species probably exceeds that of the stable.

5. The above remarks are equally applicable to all the higher divisions of plants. Some genera and orders are as natural, and as limitable by characters, as are some species; others again, though they contain many very well-marked subordinate plans of construction, yet are so connected by intermediate forms with otherwise very different genera or orders, that it is impossible to limit them naturally. And as some of the best marked and limited species consist of a series of badly marked and illimitable varieties, so some of the most natural† and limitable orders

* Mr. Darwin, after a very laborious analysis of many Floras, finds that the species of large genera are relatively more variable than those of small; a result which I was long disposed to doubt, because of the number of variable small genera and the fact that monotypic genera seldom have their variations recorded in systematic works, but an examination of his data and methods compels me to acquiesce in his statement. It has also been remarked (Bory de Saint-Vincent, Voy. aux Quatre Iles de l'Afrique) that the species of islands are more variable than those of continents, an opinion I can scarcely subscribe to, and which is opposed to Mr. Darwin's facts, inasmuch as insular Floras are characterized by peculiar genera, and by having few species in proportion to genera. Bisexual trees and shrubs are generally more variable than unisexual, which however is only a corollary from what is stated above regarding plants of simple structure of flower. On the whole, I think herbs are more variable than shrubby plants, and annuals than perennials. It would be curious to ascertain the relative variableness of social and scattered plants. The individuals of a social plant, in each area it is social upon, are generally very constant, but individuals from different areas often differ much. The *Pinus sylvestris*, *Mughus*, and *uncinata* are cases in point, if considered as varieties of one; as are the Cedars of Atlas, Algeria, and the Himalaya.

† It should be borne in mind that the term *natural*, as applied to orders or other groups, has often a double significance; every natural order is so in the sense of each of its members being more closely related to one or more of its own group than to any of another; but the term is often used to designate an easily limited natural order, that is, one whose members are so very closely related to each other by conspicuous peculiarities that its differential characters can be expressed, and itself

and genera may respectively consist of only undefinable groups of genera or of species. For instance, both *Gramineæ* and *Compositæ* are, in the present state of our knowledge, absolutely limited orders, and extremely natural ones also; but their genera are to a very eminent degree arbitrarily limited, and their species extremely variable. *Orchideæ* and *Leguminosæ* are also well-limited orders (though not so absolutely as the former), but they, on the contrary, consist of comparatively exceedingly well-marked genera and species. *Melanthaceæ* and *Scrophularineæ*, on the other hand, are not limitable as orders, and contain very many differently constructed groups; but their genera, and to a great extent their species also, are well-marked and limitable. The circumstance of a group being either isolated or having complex relations, is hence no indication of its members having the same characters.

Again, as with species, so with genera and orders, we find that upon the whole those are the best limited which consist of plants of complex floral structure: the orders of Dicotyledons are better limited than those of Monocotyledons, and the genera of Dichlamydeæ than those of Achlamydeæ.*

always recognized; these may be called *objective* orders; *Orchideæ* and *Gramineæ* are examples. Any naturalist, endowed with fair powers of observation and generalization, recognizes the close affinity between a pseudobulbous epiphytical, and a terrestrial tuberous-rooted Orchid, or between the Bamboo and Wheat, though the differences are exceedingly great in habit and in organs of vegetation and reproduction. Other orders are as natural and may be as well limited, but having no conspicuous characters in common, and presenting many subordinate distinct plans of structure, may be regarded as *subjective*. Such are *Ranunculaceæ* and *Leguminosæ*, of which a botanist must have a special and extensive knowledge before he can readily recognize very many of their members. No degree of natural sagacity will enable an uninstructed person to recognize the close affinity of *Clematis* and *Ranunculus*, or of *Acacia* and *Cytisus*, though these are really as closely related as the Orchids and Grasses mentioned above. We do not know why some orders are subjective and some objective; but if the theory of creation by variation is a true one, we ought through it to reach a solution.

* There are too many exceptions to this to admit of our concluding at once that it is attributable to any simple and uniform law of variation; but it may be explained by assuming that the degree or amount of variation is differently manifested at different epochs in the history of the group. Thus, if a genus is numerically increasing, and consequently running into varieties, it will present a group of species with complex relations *inter se;* if, on the contrary, it is numerically decreasing, such decrease must lead to the extinction of some varieties, and hence result in the better limitation of the remainder. The application of this assumption to the fact of the best limited groups being most prevalent among the higher classes (*i. e.*, among those most complicated in their organization), would at first sight appear an argument against progression, were it not for the consideration that the higher tribes of plants have in another respect proved themselves superior, in that they have not only far surpassed the lower in number of genera and species, but in individuals, and also in bulk and stature. And lastly, as all the highest orders of plants contain numerous species and often genera of as simple organization as any of the lower orders are, it follows that that physical superiority which is manifested in greater extent of variation, in better securing a succession of race, in more rapid multiplication of individuals, and even in increase of bulk, is in some senses of a higher order than that represented by mere complexity or specialization of organ.

Now my object in dwelling on this parallelism between the characteristics of individuals in relation to species, of species in relation to genera, and of genera in relation to orders, is because I consider (Introd. Essay to Fl. N. Z.) that it is to the extinction of species and genera that we are indebted for our means of resolving plants into limitable genera and orders. This view is now, I believe, generally admitted, even by those who still regard species as the immutable units of the vegetable creation; and it therefore now remains to be seen how far we are warranted in extending it to the limitation of species by the elimination of their varieties through natural causes.*

6. The evidence of variability thus deduced from a rapid general survey of the prominent facts elicited from a study of the principles of classification, are to a certain extent tested by the behavior of plants under cultivation, which operates either by hastening the processes of nature (in rapidly inducing variation), or by effecting a prolepsis or anticipation of those processes (in producing sports, *i. e.* better marked varieties, without graduated stages), or by placing the plant in conditions to which it would never have been exposed in the ordinary course of natural events, and which eventually either kill it or give origin to a series of varieties which might otherwise have never existed.†

* It follows as a corollary to the proposition (that species, etc., are naturally rendered limitable by the destruction of varieties), that there must be some intimate relation between the rate of increase and the duration of genera (or other groups of species) on the one hand, and the limitability of their species on the other. Thus, when a genus consists of a multitude of illimitable forms, we may argue with much plausibility that it is on the increase, because no intermediates have as yet been destroyed, and that the birth of individuals and the production of new forms is proceeding at a greater proportional rate than in an equally large genus of which the species are limitable.

† My friend Mr. Wallace treats of animals under domestication, not only as if they were in very different physical conditions from those in a state of nature, inasmuch as every sense and faculty is continually fully exercised and strengthened by wild animals, whilst certain of these lie dormant in the domesticated, but also as if they were subject to the influence of fundamentally different laws. He says, "No inferences as to varieties in a state of nature can be deduced from the observation of those occurring among domestic animals. The two are so much opposed that what applies to the one is almost sure not to apply to the other." But, in the first place, of the same species of wild animals some families must be placed where certain faculties and senses are far more exercised than others, and the difference in this respect between the conditions of many families of wild animals is as great as those between many wild and tame families; and secondly, other senses and faculties, latent and unknown in the wild animal, but which are as proper to the species as any it exercised in its wild state, are manifested or developed by it under domestication. An animal in a state of nature is not then, as Mr. Wallace assumes, "in the full exercise of every part of its organization;" were it so, it could not vary or alter with altered conditions, nor could other faculties remain to be called into play under domestication. The tendency of species when varying cannot be to depart from the original type in a wild condition and to revert to it under domestication, for man cannot invert the order of nature, though he may hasten or retard some of its processes.

7. Now the prominent phenomena presented by species under cultivation are analogous in kind and extent to those which we have derived from a survey of the affinities of plants in a state of nature: a large number remain apparently permanent and unalterable, and a large number vary indefinitely. Of the permanent there is little to remark, except that they belong to very many orders of plants, nor are they always those which are permanent in a state of nature. Many plants, acknowledged by all to be varieties, may be propagated by seed or otherwise, when their offspring retains for many successive generations the characters of the variety. On the other hand, species which have remained immutable for many generations under cultivation, do at length commence to vary, and having once begun, are thereafter peculiarly prone to vary further.

8. The variable cultivated species present us with the most important phenomena for investigating the laws of mutability and permanence; but these phenomena are so infinitely varied, complex, and apparently contradictory, as to defeat all attempts to elucidate the history of any individual case of variation by a study of its phases alone. It would often appear doubtful whether the natural operations of a plant tend most to induce or to oppose variation; and we hence find the advocates of original permanent creations, and those of mutable variable species, taking exactly opposite views in this respect, the truth, I believe, being that both are right. Nature has provided for the possibility of indefinite variation, but she regulates as to extent and duration; she will neither allow her offspring to be weakened or exhausted by promiscuous hybridization and incessant variation, nor will she suffer a new combination of external conditions to destroy one of these varieties without providing a substitute when necessary; hence some species remain so long hereditarily immutable as to give rise to the doctrine that all are so normally, while others are so mutable as to induce a belief in the very opposite doctrine, which demands incessant lawless change.

9. It would take far too long a time were I to attempt any analysis of the phenomena of cultivation, as illustrative of those of variability in a state of nature. There are however some broad facts which should be borne in mind in treating of variation by cross impregnation and hybridity.

10. Variation is effected by graduated changes; and the tendency of varieties, both in nature and under cultivation, when further varying, is rather to depart more and more widely from the original type, than to revert to it: the best marked varieties of a wild species occurring on the confines of the area the species inhabits, and the best marked varieties of the cultivated species being those last produced by the gardener. I am aware

that the prevalent opinion is that there is a strong tendency in cultivated, and indeed in all varieties, to revert to the type from which they departed; and I have myself quoted this opinion, without questioning its accuracy,* as tending to support the views of those who regard species as permanent. A further acquaintance with the results of gardening operations leads me now to doubt the existence of this centripetal force in varieties, or at least to believe that in the phrase "reversion to the wild type," many very different phenomena are included. In the first place, the majority of cultivated vegetables and cerealia, such as the Cabbage and its numerous progeny, and the varieties of wall-fruit, show when neglected no disposition to assume the characters of the wild states of these plants;† they certainly degenerate, and even die if Nature does not supply the conditions which man (by anticipation of her operations, or otherwise) has provided; they become stunted, hard, and woody, and resemble their wild progenitors in so far as all stunted plants resemble wild plants of similar habit; but this is not a reversion to the original type, for most of these cultivated races are not *merely* luxuriant forms of the wild parent. In neglected fields and gardens we see plants of Scotch Kale, Brussels Sprouts, or Kohl-rabi, to be all as unlike their common parent, the wild *Brassica oleracea*, as they are unlike one another; so, too, most of our finer kinds of apples, if grown from seed, degenerate and become crabs, but in so doing they become crab states of the varieties to which they belong, and do not revert to the original wild Crab-apple. And the same is true to a great extent of cultivated Roses, of many varieties of trees, of the Raspberry, Strawberry, and indeed of most garden plants. It has also been held, that by imitating the conditions under which the wild state of a cultivated variety grows, we may induce that variety to revert to its original state; but, except in the false sense of reversion above explained, I doubt if this is supported by evidence. Cabbages grown by the seaside are not more like wild Cabbages than those grown elsewhere, and if cultivated states disseminate themselves along the coast, they there retain their cultivated form. This is however a subject which would fill a volume with most instructive matter for reflection, and which receives a hundredfold more illustration from the Animal than from the Vegetable Kingdom. I can here only indicate its bearing on the doctrine of variation, as evidence that Nature operates upon mutable forms by allowing great variation, and displaying

* Fl. N. Zeal., Introd. Essay, p. x, and Flora Indica, Introduction, p. 14.

† Hence the great and acknowledged difficulty of determining the wild parent species of most of our cultivated fruits, cerealia, etc., and in fact of almost every member of our Flora Cibaria. This would not be so were their any disposition in the neglected cultivated races to revert to the wild form.

little tendency to reversion.* With this law the suggestive observation of M. Vilmorin well accords, that when once the constitution of a plant is so broken that variation is induced, it is easy to multiply the varieties in succeeding generations.

It may be objected to this line of argument that our cultivated plants are, as regards their constitution, in an artificial condition, and are, if unaided, incapable of self-perpetuation; but an artificially induced condition of constitution is not necessarily a diseased or unnatural one, and, so far as our cultivated plants are concerned, all we do is to place them under conditions which Nature does not provide *at the same particular place and time.* That Nature might supply the conditions at other places and times may be inferred from the fact that the plant is found to be provided with the means of availing itself of them when provided, while at the same time it retains all its functions, not only unimpaired, but in many cases in a more highly developed state. We have no reason to suppose that we have violated Nature's laws in producing a new variety of wheat,—we may have only anticipated them; nor is its constitution impaired because it cannot, unaided, perpetuate its race; it is in as souud and unbroken health and vigor during its life as any wild variety is, but its offspring has so many enemies that they do not perpetuate its race. In the case of annual plants, those only can secure the succession of their species which produce more seeds annually than can be eaten by animals or destroyed by the elements. Cultivated wheat will grow and ripen its seed in almost all soils and climates, and as its seeds are produced in great abundance, and can be preserved alive in any quantity, in the same climate, and for many years, it follows that it is not to the artificial or peculiar condition of the plant itself, and still less to any change effected by man upon it, that its annual extinction is due, but to causes that have no effect whatever upon its own constitution, and over which its constitutional peculiarities can exercise no control.

11. Again, the phenomena of cross impregnation amongst individuals of all species appear, according to Mr. Darwin's accurate observations, to have been hitherto much underrated, both as to extent and importance. The prominent fact that the stamens and pistil are so often placed in the same flower, and come to maturity at the same epoch, has led to the doctrine that flowers are usually self-impregnated, and that the effect is a conservative one as regards the permanence of specific forms. The ob-

* It is not meant by this that any character of a species which may be lost in its variety never reappears in the descendants of the latter, for some occasionally do so in great force; what is meant is, that the newly acquired characters of the variety are never so entirely obliterated that it has no longer a claim to be considered a variety.

servations of Carl Sprengel and others have, however, proved that this is not always the case, and that while Nature has apparently provided for self-fertilization, she has often insiduously counteracted its operation, not only by placing in flowers lures for insects which cross-fertilize them, but often by interposing insuperable obstacles to self-fertilization, in the shape of structural impediments to the access of the pollen to the stigma of its own flower.* In all these instances the double object of Nature may be traced; for self-impregnation (or "breeding in"), while securing identity of form in the offspring, and hence hereditary permanence, at the same time tends to weakness of constitution, and hence to degeneracy and extinction: on the other hand, cross-impregnation, while tending to produce diversity of form in the offspring, and hence variation and apparent mutability, yet by strengthening the offspring favors longevity and apparent permanence of specific type. The ultimate effect of all these operations is of course favorable to the hypothesis that variability is the rule, and permanence the exception, or at any rate only a transitory phenomenon.

12. Hybridization, or cross-impregnation between species or very well marked varieties, again, is a phenomenon of a very different kind, however similar it may appear in operation and analogous in design. Hybridizable genera are rarer that is generally supposed, even in gardens, where they are so often operated upon, under circumstances the most favorable to the production of a hybrid, and unfavorable to self-impregnation. Hybrids are almost invariably barren, and their characters are not those of new varieties. The obvious tendency of hybridization between varieties or other very closely allied forms (in which case the offspring may be fertile) is not to enlarge the bounds of variation, but to contract them; and if between very different forms, it will only tend to confound these. That some supposed species may have their origin in hybridization cannot be denied, but we are now dealing with phenomena on a large scale, and balancing the tendencies of causes uniformly acting, whose effects are unmistakable, and which can be traced throughout the Vegetable Kingdom. In gardening operations the number of hybridized genera is small, their offspring doomed, and since they are more readily impregnated by the pollen of either parent than by their own, or by that of any other plant,† they eventu-

* Thus, in *Lobelia fulgens*, the pollen is entirely prevented by natural causes from reaching the stigma of its own flower. In kidney beans impregnation takes place imperfectly except the carina is worked up and down artificially, which is effected by bees, who may thus either impregnate the flower with its own pollen or with that brought from another plant. I am indebted to Mr. Darwin for both these facts: see 'Gardener's Chronicle,' 1853, p. 828.

† A very able and careful experimenter, M. Naudin, performed a series of experiments at the Jardin des Plantes at Paris, in order to discover the duration of the

ally revert to one of their parents: on the other hand, the number of varieties is incalculable, the power to vary further is unimpaired in their progeny, and these tend to depart further and further in sensible properties from the original parent.

In conformity with my plan of starting from the variable and not the fixed aspect of Nature, I have now set down the prominent features of the Vegetable Kingdom, as surveyed from this point of view. From the preceding paragraphs the evidence appears to be certainly in favor of proneness to change in individuals, and of the power to change ceasing only with the life of the individual; and we have still to account for the fact that there are limits to these mutations, and laws that control the changes both as to degree and kind; that species are neither visionary nor even arbitrary creations of the naturalist; that they are, in short, realities, whether only temporarily so or not.

13. Granting then that the tendency of nature is first to multiply forms of existing plants by graduated changes, and next by destroying some to isolate the rest in area and in character, we are now in a condition to seek some theory of the *modus operandi* of Nature that will give temporary permanence of character to these changelings. And here we must appeal to theory or speculation; for our knowledge of the history of species in relation to one another, and to the incessant mutations of their environing physical conditions, is far too limited and incomplete to afford data for demonstrating the effects of these in the production of any one species in a native state.

Of these speculations by far the most important and philosophical is that of the delimitation of species by natural selection, for which we are indebted to two wholly independent and original thinkers, Mr. Darwin and Mr. Wallace.* These authors assume that all animal and vegetable forms are variable, that the average amount of space and annual supply of food for each species (or other group of individuals) is limited and constant, but that the increase of all organisms tends to proceed annually in a geometrical ratio; and that, as the sum of organic life on the surface of the globe does not increase, the individuals annually destroyed must be incalculably great; also that each species is ever warring against many enemies, and only holding its own by a slender tenure. In the ordinary course of nature this

progeny of fertile hybrids. He concludes that the fertile posterity of hybrids disappears, to give place to the pure typical form of one or other parent. "Il se peut sans doute qu'il y ait des exceptions à cette loi de retour, et que certains hydrides, à la fois très-fertiles et très-établis, tendent à faire souche d'espèce; mais le fait est loin d'être prouvé. Plus nous observons les phénomènes d'hybridité, plus nous inclinons à croire que les espèces sont indissolublement liées à une fonctions dans l'ensemble des choses, et que c'est le rôle même assigné à chacune d'elles qui en détermine la forme, la dimension et la durée." (Annales des Sc. Nat., sér. 4, v. 9.)

* Journal of the Linnean Society of London, Zoology, vol. iii, p. 45.

annual destruction falls upon the eggs or seeds and young of the organisms, and as it is effected by a multitude of antagonistic, ever-changing natural causes, each more destructive of one organism than of any other, it operates with different effect on each group of individuals, in every locality, and at every returning season. Here then we have an infinite number of varying conditions, and a superabundant supply of variable organisms, to accommodate themselves to these conditions. Now the organisms can have no power of surviving any change in these conditions, except they are endowed with the means of accommodating themselves to it. The exercise of this power may be accompanied by a visible (morphological) change in the form or structure of the individual, or it may not, in which case there is still a change, but a physiological one, not outwardly manifested; but there is always a morphological change if the change of conditions be sudden, or when, through lapse of time, it becomes extreme. The new form is necessarily that best suited to the changed condition, and as its progeny are henceforth additional enemies to the old, they will eventually tend to replace their parent form in the same locality. Further, a greater proportion of the seeds and young of the old will annually be destroyed than of the new, and the survivors of the old, being less well adapted to the locality, will yield less seed, and hence have fewer descendants.

In the above operations Nature acts slowly on all organisms, but man does so rapidly on the few he cultivates or domesticates; he selects an organism suited to his own locality, and by so modifying its surrounding conditions that the food and space that were the share of others falls to it, he ensures a perpetuation of his variety, and a multiplication of its individuals, by means of the destruction of the previous inhabitants of the same locality; and in every instance, where he has worked long enough, he finds that changes of form have resulted far greater than would suffice to constitute conventional species amongst organisms in a state of nature, and he keeps them distinct by maintaining these conditions.

Mr. Darwin adduces another principle in action amongst living organisms as playing an important part in the origin of species, viz., that the same spot will support most life when peopled with very diverse forms, as is exemplified by the fact that in all isolated areas the number of classes, orders, and genera is very large in proportion to that of species.

§ 3. *On the General Phenomena of Distribution in Area.*

Turning now to another class of facts, those that refer to the distribution of plants on the surface of the globe, the following are the most obvious:—

14. The most prominent feature in distribution is that circumscription of the area of species, which so forcibly suggests the hypothesis that all the individuals of each species have sprung from a common parent, and have spread in various directions from it. It is true that the area of some (especially cryptogamic and aquatic plants) is so great that we cannot indicate any apparent centre of diffusion, and that others are so sporadic that they appear to have had many such centres; but these species, though more numerous than is usually supposed, are few in comparison with those that have a definite or circumscribed area.

With respect to this limitation in area,* species do not essentially differ from varieties on the one hand, or from genera and higher groups on the other; and indeed, in respect of distribution, they hold an exactly intermediate position between them, varieties being more restricted in locality than species, and these again more than genera.

The universality of this feature (of groups having defined areas) affords to my mind all but conclusive evidence in favor of the hypothesis of similar forms having had but one parent, or pair of parents. And further, this circumscription of species and other groups in area, harmonizes well with that principle of divergence of form, which is opposed to the view that the same variety or species may have originated at different spots. It also follows that, as a general rule, the same species will not give rise to a series of similar varieties (and hence species) at different epochs; whence the geological evidence of contemporaneity derived from identity of fossil forms may be relied upon.

The most obvious cause of this limitation in area no doubt exists in the well-known fact that plants do not necessarily inhabit those areas in which they are constitutionally best fitted to thrive and to propagate; that they do not grow where they would most like to, but where they can find space and fewest enemies. We have seen (13) that most plants are at warfare with one or more competitors for the area they occupy, and that both the number of individuals of any one species and the area it covers are contingent on the conditions which determine these remaining so nicely balanced that each shall be able at least to

* It is a remarkable fact that there are some striking anomalies in the distribution of plants into provinces, as compared with animals. Thus there is no peculiarity in the vegetation of Australia to be compared with the rarity of placental mammals, nor with the fact of so many of the mammals, birds, and fish of Tasmania differing from those of the continent of Australia. Nearer home, we find the basin of the Mediterranean with a tolerably uniform flora on the European and North African sides, but these ranking as different zoological provinces. The much narrower delimitation in area of animals than plants, and greater restriction of faunas than floras, should lead us to anticipate that plant types are, geologically speaking, more ancient and permanent than the higher animal types are, and so I believe them to be, and I would extend the doctrine even to plants of highly complex structure.

hold its own, and not succumb to the enervating or etiolating or smothering influences of its neighbors. The effects of this warfare are to extinguish some species, to spare only the hardier races of others, and especially to limit the remainder both as to area and characters. Exceptions occur in plants suited to very limited or abnormal conditions, such as desert plants, the chief obstacles to whose multiplication are such inorganic and principally atmospheric causes as other plants cannot overcome at all; such plants have no competitors, are generally widely distributed, and not very variable.*

15. The three great classes of plants, Acotyledons, Monocotyledons, and Dicotyledons (Gymnospermous and Angiospermous), are distributed with tolerable equality over the surface of the globe, inasmuch as we cannot indicate any of the six continents (Europe, Asia, Africa, North and South America, and Australia) as being peculiarly rich in one to the exclusion of another. Further, the distribution of some of the larger orders is remarkably equable, as *Compositæ*, *Leguminosæ*, *Gramineæ*, and others; facts which (supposing existing species to have originated in variation) would seem to indicate that the means of distribution have overcome, or been independent of the existing apparent impediments, and that the power of variation is equally distributed amongst these classes, and continuously exerted under very different conditions. I do not mean that all the classes are equally variable, but that each displays as much variety in one continent as in another.

16. Those classes and orders which are the least complex in organization are the most widely distributed, that is to say, they contain a larger proportion of widely diffused species. Thus the species of Acotyledons are more widely dispersed than those of Monocotyledons, and these again more so than those of Dicotyledons; so also the species of *Thallophytes* are among the most widely dispersed of Acotyledons, the *Gramineæ* of Monocotyledons, and the *Chenopodiaceæ* of Dicotyledons. This tendency of the least complex species to be most widely diffused is most marked in Acotyledons, and least so in Dicotyledons,† a fact which is analogous to that already stated (4), that the least complex are also the most variable.

* Though invariable forms, they may be, and often are, themselves varieties or races of a species that inhabits more fertile spots, as *Poa bulbosa*, which is a very well-marked and constant form of *P. pratensis*, occurring in dry sandy soil, from England to Northwestern India, its "meadow" relative being a very variable species in the same countries, and always struggling for existence amongst other grasses, etc.

† Very much, no doubt, because of the difficulty in classifying Dicotyledons by complexity of organization; in other words, of our inability to estimate in a classificatory point of view the relative value of the presence or absence of organs in plants, where many are present, and where those of low morphological importance may have a comparatively high physiological significance.

17. Though we rarely find the same species running into the same varieties at widely sundered localities (unless starved or luxuriant forms be called varieties), yet we do often find a group of species represented in many distant places by other groups of allied forms; and if we suppose that individuals of the parent type have found their way to them all, the theory that existing species have originated in variation, and that varieties depart further from the parent form, will account for such groups of allied species being found at distant spots; as also for these groups being composed of representative species and genera.

18. No general relations have yet been established between the physical conditions of a country and the number of species or varieties which it contains, further than that the tropical and temperate regions are more fertile than the polar, and that perennial drought is eminently unfavorable to vegetation. It is not even ascertained whether the tropical climates produce more species than the temperate.

19. Though we cannot explain the general relations between the vegetation and physical condition of any two countries that contrast in these respects, we may conclude as a general rule that those tracts of land present the greatest variety in their vegetation that have the most varied combinations of conditions of heat, light, moisture, and mineral characters. It is, in the present state of our knowledge, impossible to measure the amount of the fluctuations of these conflicting conditions in a given country, nor if we could can we express them symbolically or otherwise so as to make them intelligible exponents of the amount of variety in the vegetation they affect; but the following facts in general distribution appear to me to be favorable to the idea that there is such a connection.

There are certain portions of the surface of the globe characterized by a remarkable uniformity in their phænogamic vegetation. These may be luxuriantly clothed, and abound in individuals, but are always poor in species. Such are the cooler temperate and subarctic lake regions of North America, Fuegia and the Falkland Islands, the Pampas of Buenos Ayres, Siberia and North Russia, Ireland and Western Scotland, the great Gangetic plain, and many other tracts of land. Now all these regions are characterized by a great uniformity in most of their physical characters, and an absence of those varying conditions which we assume to be stimulants to variation in a locality. On the other hand, it is in those tracts that have the most broken surface, varied composition of rocks, excessive climate (within the limits of vegetable endurance), and abundance of light, that the most species are found, as in South Africa, many parts of Brazil and the Andes, Southern France, Asia Minor, Spain, Algeria, Japan, and Australia.

20. The Polar regions are chiefly peopled from the colder temperate zones, and the species from the latter which have spread into them are very variable, but only within comparatively small limits, particularly in stature, color, and vesture. Many of these polar and colder temperate plants are also found, together with other species closely allied to them, on the mountains of the warm temperate, and even tropical zones; to which it is difficult to conceive that they can have been transported by agencies now in operation.

21. The floras of islands present many points of interest. The total number of species they contain seems to be invariably less than an equal continental area possesses, and the relative numbers of species to genera (or other higher groups) is also much less than in similar continental areas.

The further an island is from a continent, the smaller is its flora numerically, the more peculiar is its vegetation, and the smaller its proportion of species to genera. In the case of very isolated islands, moreover, the generic types are often those of very distant countries, and not of the nearest land. Thus the St. Helena and Ascension forms are not so characteristic of tropical Africa as of the Cape of Good Hope. Those of Kerguelen's Land are Antarctic American, not African nor Indian. The Sandwich Islands contain many Northwest American and some New Zealand forms. Japan presents us with many genera and species unknown except to the *eastward* of the Rocky Mountains, in North America.* So too American, Abyssinian, and even South African genera and species are found in Madeira and the Canary Islands; and Fuegian ones in Tristan d'Acunha.

22. There is a strict analogy in this respect between the floras of islands and those of lofty mountain-ranges, no doubt in both cases owing to the same causes. Thus, as Japan contains various peculiar N. E. American species which are not found in N. W. America nor elsewhere on the globe, and the Canaries and Azores possess American genera not found in Europe nor Africa, so the lofty mountains of Borneo contain Tasmanian and Himalayan representatives; the Himalayas contain Andean, Rocky Mountain, and Japanese genera and species; and the alps of Victoria and Tasmania contain assemblages of New Zealand, Fuegian, Andean, and European genera and species. We cannot account for any of these cases of distribution between islands and mountains except by assuming that the species and genera common to these distant localities have found their way across the intervening spaces under conditions which no longer exist.

* Whilst these sheets are passing through the press, I have been informed by Professor Asa Gray that the flora of Japan and N. E. Asia is much more closely allied to that of the Northern United States than to that of America west of the Rocky Mountains.

23. There is much to be observed in the condition and distribution of the introduced or naturalized plants of a country, which may be applied to the study of the origin of its indigenous vegetation. The greater proportion of these are the annual and other weeds of cultivated land, and plants which attach themselves to nitrogenous soils; naturalized perennials, shrubs, and trees occur consecutively in rapidly diminishing proportions. I can find no decided relation between complexity of structure and proneness to migrate, nor much between facilities for transport or power of endurance or vitality in the seed, and extent of distribution by artificial means. I shall return to this subject (which I have elsewhere discussed at length with reference to the Galapagos Archipelago*) when treating of the naturalized plants of Australia.

24. I venture to anticipate that a study of the vegetation of islands with reference to the peculiarities of their generic types on the one hand, and of their geological condition (whether as rising or sinking) on the other, may, in the present state of our knowledge, advance the subjects of distribution and variation considerably. The incompleteness of the collections at my command from the Polynesian islands, has frustrated my attempts to illustrate this branch of inquiry by extending my researches from the Australian Flora over that of the Pacific. I may however indicate as a general result, that I find the sinking islands, those (so determined by Darwin's able investigations) characterized as atolls, or as having barrier reefs, to contain comparatively fewer species and fewer peculiar generic types than those which are rising. Thus, commencing from the east coast of Africa, I find in the Indian Ocean the following islands marked in Darwin's chart† as bounded with fringing reefs or active volcanos, and hence rising:—The Seychelles, Madagascar, Mauritius, Bourbon, Ceylon, the Andamans, Nicobar, and Sumatra; the vegetation of all which is characterized by great diversity and much peculiarity of generic type: whereas those marked as atolls or barrier reefs, as the Maldives, Laccadives, and Keeling Island, contain few species, and those the same as grow on the nearest continents. In the Pacific Ocean, again, the groups of islands most remarkable for their ascertained number of very peculiar generic types are the Sandwich group, Galapagos, Juan Fernandez, Loochoo and Bonin, all of which are rising, and most have active volcanos: those with the least amount of peculiarity are the Society group and Fijis, both of which are sinking. In the present state of our knowledge it is not safe to lay much stress on these apparent facts, especially as the New Hebrides and New Caledonia, which lie very close together, and both, I believe,

* Linn. Trans., xx, 235.

† See his works on volcanic islands and on coral reefs.

contain much peculiarity, are in opposite geological conditions, the Hebrides rising and Caledonia sinking; and the Friendly* and Fiji groups, equally near one another, and with, I suspect, very similar vegetation, are also represented as being in opposite conditions. On the other hand, in the whole of the group including the Low Archipelago and the Society Islands, extending over more than 2000 miles, I observe but one spot,† namely, Elizabeth Island, a mere speck of land, but which is the only known habitat of one of the most remarkable genera of *Compositæ*.‡

25. Many of the above facts in the general distribution of species cannot be wholly accounted for by the supposition that natural causes have dispersed them over such existing obstacles as seas, deserts, and mountain-chains; moreover, some of these facts are opposed to the theory that the creation of existing species has taken place subsequent to the present distribution of climates, and of land and water, and to that of their dispersion having been effected by the now prevailing aquatic, atmospheric, and animal means of transport.

Similar climates and countries, even when altogether favorably placed for receiving colonists from each other, and with conditions suitable to their reciprocal exchange, do not, as a rule, interchange species. Causes now in operation will not account for the fact that only 200 of the New Zealand flowering plants are common to Australia, and still less for the contrasting one that the very commonest, most numerous, and universally distributed Australian genera and species, as *Casuarina*, *Eucalyptus*, *Acacia*, *Boronia*, *Helichrysum*, *Melaleuca*, etc., and all the Australian *Leguminosæ* (including a European genus and species), are absent from New Zealand. Causes now in operation cannot be made to account for a large assemblage of flowering plants characteristic of the Indian peninsula being also inhabitants of tropical Australia, while not one characteristic Australian genus has ever been found in the peninsula of India. Still less will these causes account for the presence of Antarctic and European species in the Alps of Tasmania and Victoria, or for the reappearance of Tasmanian genera on the isolated lofty mountain of Kina-Balou, in Borneo.

* I find that there is a remarkable difference between the floras of the New Hebrides and Caledonia on the one hand, and those of the Fiji islands and those to the east of them on the other. In the former, New Zealand and Australian types abound; in the latter, almost exclusively Indian forms. The differences between the floras of Fiji, Samoa, Tonga, Tahiti, and that of India, are in species and not in genera, and many species are common to all.

† Mr. Darwin has left Aurora Island (another of the group) uncolored, on account of the doubtful evidence regarding it, which however is in favor of its being in the same condition as Elizabeth's Island. From a list of species communicated by Mr. Dana, it appears to contain no peculiar plants.

‡ *Fitchia*. See Lond. Journ. Bot. 1845, iv, p. 640, t. 23, 24. [A specimen of this plant was gathered by Prof. Dana on the mountains of Tahiti.—Eds.]

These and a multitude of analogous facts have led to the study of two classes of agents, both of which may be reasonably supposed to have had a powerful effect in determining the distribution of plants; these are changes of climates, and changes in the relative positions and elevations of land.

26. Of these, that most easy of direct application is the effect of humidity in extending the range of species into regions characterized by what would otherwise be to them destructive temperatures.

I have, in the 'Antarctic Flora,' shown that the distribution of tropical forms is extended into cold regions that are humid and equable further than into such as are dry and excessive; and, conversely, that temperate forms advance much further into humid and equable tropical regions than into dry and excessive ones; and I have attributed the extension of Tree-ferns, Epiphytal Orchids, Myrtaceæ, etc., into high southern latitudes, to the moist and equable climate of the south temperate zone. I have also shown how conspicuously this kind of climate influences the distribution of mountain plants in India, where tropical forms of Laurel, Fig, Bamboo, and many other genera, ascend the humid extratropical mountains of Eastern Bengal and Sikkim to fully 9000 feet elevation; and temperate genera, and in some cases species, of Quercus, Salix, Rosa, Pinus, Prunus, Camellia, Rubus, Kadsura, Fragaria, Æsculus, etc., descend the mountains even to the level of the sea, in lat. 25°. In a tropical climate the combined effects of an equable climate and humidity in thus extending the distribution of species, often amount to 5000 feet in elevation or depression (equivalent to 15° Fahr. of isothermals in latitude), a most important element in our speculations on the comparative range of species under existing or past conditions; and when to this is added that the average range in altitude of each Himalayan tropical and temperate and alpine species of flowering plant is 4000 feet, which is equivalent to 12° of isothermals of latitude, we can understand how an elevation of a very few thousand feet might, under certain climatic conditions, suffice to extend the range of an otherwise local species over at least 28° parallels of latitude, and how a proportionally small increase of elevation in a meridional chain where it crosses the Equator, may enable temperate plants to effect an easy passage from one temperate zone to the other.

27. To explain more fully the present distribution of species and genera in area, I have recourse to those arguments which are developed in the Introductory Essay to the New Zealand Flora, and which rest on geological evidence, originally established by Sir Charles Lyell, that certain species of animals have survived great relative changes of sea and land. This doctrine, which I in that Essay endeavored to expand by a study of the

distribution of existing southern species, has, I venture to think, acquired additional weight since then, from the facts I shall bring forward under the next head of Geological Distribution, and which seem to indicate that many existing orders and genera of plants of the highest development may have flourished during the Eocene and Cretaceous periods, and have hence survived complete revolutions in the temperature and geography of the middle and temperate latitudes of the globe.

28. Mr. Darwin has greatly extended in another direction these views of the antiquity of many European species, and their power of retaining their *facies* unchanged during most extensive migrations, by his theory of the simultaneous extension of the glacial temperature in both hemispheres, and its consequent effect in cooling the tropical zone. He argues that, under such a cold condition of the surface of the globe, the temperate plants of both hemispheres may have been almost confined to the tropical zone, whence afterwards, owing to an increment of temperature, they would be driven up to the mountains of the tropics, and back again to those higher temperate latitudes where we now find most of them. I have already (New Zealand Essay) availed myself of the hypothesis of an austral glacial period, to account for Antarctic species being found on the alps of Australia, Tasmania, and New Zealand; and if as complete evidence of such a proportionally cooled state of the intertropical regions were forthcoming as there is of a glacial condition of the temperate zones, it would amply suffice to account for the presence of European and Arctic species in the Antarctic and south temperate regions, and of the temperate species of both hemispheres on the mountains of intermediate tropical latitudes.

On the other hand, we have sufficient evidence of many of what are now the most tropical orders of plants having inhabited the north temperate zone before the glacial epoch; and it is difficult to conceive how these orders could have survived so great a reduction of the temperature of the globe as should have allowed the preglacial temperate flora to cross the Equator in any longitude. It is evident that, under such cold, the most tropical orders must have perished, and their re-creation after the glacial epoch is an inadmissible hypothesis.*

* The question of the state of the mean temperature of the globe during comparatively recent geological periods is yearly deriving greater importance in relation to the problem of distribution. Upon this point geologists are not altogether clear, nor at one with the masters of physical science. Lyell (Principles, ed. ix, chap. vii) attributes the glacial epoch to such a disposition of land and sea as would sufficiently cool the temperate zones; and he implies that this involves or necessitates a lowering of the mean temperature of the whole globe. Another hypothesis is, that there was a lowering of the mean temperature of the globe wholly independent of any material change in the present relations of sea and land, which cold induced the glacial epoch. A third theory is that such a redisposition of land and sea as would induce a glacial epoch in our hemisphere need not be great, nor necessitate a decrement of the mean temperature of the whole earth.

29. It remains then to examine whether, supposing the glacial epoch of the northern and southern hemispheres to have been contemporaneous, the relations of land and sea may not have been such as that a certain meridian may have retained a tropical temperature near the Equator, and thus have preserved the tropical forms. Such conditions might perhaps be attained by supposing two large masses of land at either pole, which should contract and join towards the Equator, forming one meridional continent, while one equatorial mass of land should be placed at the opposite meridian. If the former continent were traversed by a meridional chain of mountains, and so disposed that the polar oceanic currents should sweep towards the Equator for many degrees along both its shores, its equatorial climate would be throughout far more temperate than that of the opposite equatorial mass of land, whose climate would be tropical, insular, and humid.

30. The hypothesis of former mountain chains having afforded to plants the means of migration, by connecting countries now isolated by seas or desert plains, is derived from the evidence afforded by geology of the extraordinary mutation in elevation that the earth's surface has experienced since the appearance of existing forms of animals and plants. In the Antarctic Flora I suggested as an hypothesis that the presence of so many Arctic-American plants in Antarctic America might be accounted for by supposing that the now depressed portions of the Andean chain had, at a former period, been so elevated that the species in question had passed along it from the north to the south temperate zone;* and there are some facts in the distribution of species common to the mountain floras of the Himalaya and Malay Islands, and of Australia and Japan, that would well accommodate themselves to a similar hypothesis. Of such submerged meridional lands we have some slender evidence in the fact that, in the meridian of Australia and Japan, we have, first, the north-west coast of Australia sinking, together with the Louisiade archipelago to its north; then, approaching the line, the New Ireland group is sinking, as are also the Caroline Islands, in lat 7° N. Beyond this, however, in lat. 15° N., are the Marianne Islands (rising) of whose vegetation nothing is known; in 27° N., the

* The continuous extension of so many species along the Cordillera (of which detailed evidence is given in the Antarctic Flora) from the Rocky Mountains to Fuegia, is a most remarkable fact, considering how great the break is between the Andes of New Granada and those of Mexico, and that the intermediate countries present but few resting-places for alpine plants. That this depression of the chain has had a powerful effect in either limiting the extension of species which have appeared since its occurrence, or in inducing changes of climate which have extinguished species once common to the north and south, is evidenced by the fact that a number of Fuegian and South Chili plants extend northward as alpines to the very shores of the Gulf of Mexico, but do not inhabit the Mexican Andes, whilst as many Arctic species advance south to the Mexican Andes, but do not cross the intermediate depression and reappear in the Bolivian Andes.

Bonin Islands (also rising); and in 30° is Japan, with which this botanical relationship exists.

It is objected by Mr. Darwin to this line of argument (as to that on p. 15, concerning the Pacific Islands), that all these sinking areas are volcanic islands, having no traces of older rocks on them. But I do not see that this altogether invalidates the hypothesis; for many of the loftiest mountains throughout the Malayan Archipelago, New Zealand, and the Pacific Islands, are volcanic; some are active, and many attain to 14,000 feet in elevation, whilst the lower portions of some of the largest of these islands are formed of rocks of various ages.

(*To be continued.*)

ART. II.—*Some General Views on Archæology;* by A. MORLOT.*

A CENTURY scarcely has elapsed since the time when it would have been thought impossible to reconstruct the history of our globe, prior to the appearance of mankind. But, though contemporary historians were wanting during this immense pre-human era, the latter has not failed in leaving us a well-arranged series of most significant vestiges: the animal and vegetable tribes, which have successively appeared and disappeared, have left their fossil remains in the successively deposited strata. Thus has been composed, gradually and slowly, a history of creation, written, as it were, by the Creator himself. It is a great book, the leaves of which are the stratified rocks, following each other in the strictest chronological order, the chapters being the mountain-chains. This great book has long been closed to man. But science, constantly extending its realm and improving its method of induction, has taught the geologist to study those marvellous archives of creation, and we behold him now unfolding the past ages of our world, with a variety of details and a certainty of conclusions well calculated to inspire us with grateful admiration.

The development of archæology has been very similar to that of geology. Not long ago we should have smiled at the idea of reconstructing the by-gone days of our race, previous to the first beginning of history properly so called. The void was filled up, partly by representing that ante-historical antiquity as having been only of short duration, and partly by exaggerating the value and the age of those vague and confused notions which constitute tradition.

* This article is an introduction to a paper entitled, Geologico-Archæological Studies in Denmark and Switzerland, appearing in the *Bulletin de la Société Vaudoise des Sciences Naturelles*, for 1859, and of which a separate edition, comprising the present pages, will be published.

It seems to be with mankind at large as with single individuals. The recollections of our earliest childhood have entirely faded away, up to some particular event which had struck us more forcibly, and which alone has left a lasting image amidst the surrounding darkness. Thus, excepting the idea of a deluge, which exists among so many nations, and therefore appears to have originated before the migration of those same nations, the infancy of mankind, at least in Europe, has passed without leaving any recollection, and history fails here entirely: for what is history but the memory of mankind?

But, before the beginning of history, there have been life and industry, of which various monuments still exist, while others lie buried in the soil, much as we find the organic remains of former creations entombed in the strata composing the crust of the globe. The memorials of antiquity enact here a part similar to that of the fossils; and if Cuvier calls the geologist an antiquarian of a new order, we can reverse that remarkable saying, and consider the antiquarian as a geologist, applying his method to reconstruct the first ages of mankind, previous to all recollection, and to work out what may be called pre-historical history. This is archæology pure and proper. But archæology cannot be considered as coming to a full stop with the first beginning of history. For the further we recede in our historical researches, the more incomplete they become, leaving gaps which the study of the material remains helps to fill up. Archæology therefore pursues its course in a parallel line with that of history, and henceforth the two sciences mutually enlighten each other. But, with the progress of history, the part taken by archæology goes on decreasing, until the invention of printing almost brings to a close the researches of the antiquarian.

To pursue geological investigations we must first examine the present state of our planet and observe its changes; that is, we must begin by physical geography. This supplies us with a thread of induction, to guide us safely in our rambles through the passed ages of our earth, as Lyell has so admirably set forth. For the laws which govern the organic creation and the inorganic world are as invariable as the results of their combinations and permutations are infinitely varied; science revealing to us every where the perfect stability of the causes with the diversity of the forms.

So, to understand the past ages of our species, we must first begin by examining its present state, following man wherever he has crossed the waters and set his foot upon dry land: the different nations, which inhabit our earth at present, must be studied with respect to their industry, their habits and their general mode of life. We thus make ourselves acquainted with the different degrees of civilization, ranging from the highest summit

of modern development to the most abject state, hardly surpassing that of the brute. By that means ethnography supplies us with what may be called a contemporaneous scale of development, the stages of which are more or less fixed and invariable, whilst archæology traces a scale of successive development with one moveable stage, passing gradually along the whole line.*

Ethnography is consequently to archæology what physical geography is to geology, namely a thread of induction in the labyrinth of the past, and a starting point in those comparative researches of which the end is the knowledge of mankind and of its development through successive generations.

In following out the principles above laid down, the Scandinavian savans have succeeded in unravelling the leading features in the progress of pre-historical European civilization, and in distinguishing three principal eras, which they have called the *stone-age*, the *bronze-age*, and the *iron-age*.†

This great conquest in the realm of science is due chiefly to the labors of Mr. Thomsen, director of the ethnographical and archæological museums at Copenhagen‡ and to those of Mr. Nilsson, professor at the flourishing University of Lund in Sweden.§

These illustrious veterans among northern antiquaries have ascertained that our Europe, at present so civilized, was at first inhabited by tribes to whom the use of metals was totally unknown, and whose industry and domestic habits must have borne a considerable analogy to what we now see practised among certain savages. Bone, horn and especially flint were then used instead of metal for manufacturing cutting-instruments and arms. This was the *stone-age*, which might also be called the first great phase of civilization.

The earliest settlers in Europe apparently brought with them the art of producing fire. By striking iron-pyrites (sulphuret of iron) against quartz, fire can be easily obtained. But this method can only have been occasionally used, and seems to have been confined to some native tribes in Tierra del Fuego.‖ The usual mode has evidently been that of rubbing two sticks together. But on further reflection it is easy to perceive that this was a

* Some naturalists see a correspondence of the same sort between embryology and comparative anatomy; for they consider the human embryo as passing during its development through the different stages of the scale of animal creation, or, at least, as passing through the different states of the embryos of the different stages of that scale.

† The history of Danish archæology has been sketched by T. Hindenburg. See *Dansk maanedsskrift*, i. 1859.

‡ *Ledetraad til nordisk Oldkyndighed, Kjoebenhavn*, 1836. Published in English by Lord Ellesmere, under the title, "A Guide to Northern Antiquities. London, 1848."

§ Nilsson: *Scandinaviska Nordens Urinvonare.* Lund, 1838—1843.

‖ Weddell: A Voyage towards the South Pole in 1822–1824. London, 1827, p. 167

most difficult discovery, and must at all events have been preceded by a knowledge of the use of fire, as derived from the effects of lightning or from volcanic action.

The stone-age was therefore probably preceded by a period, perhaps of some length, during which man was unacquainted with the art of producing fire. This, according to Mr. Flourens, indicates that the cradle of mankind was situated in a warm climate.*

The art of producing fire has been perhaps the greatest achievement of human intelligence. The use of fire lies at the root of almost every species of industry. It enables the savage to fell trees, as it allows civilized nations to work metals. Its importance is so great, that deprived of it man would perhaps scarcely have risen above the condition of the brute. Even the ancients were sensible of this, as is witnessed by the fable of Prometheus. As to their sacred perpetual fire, its origin seems to lie in the difficulty of procuring fire, thereby rendering its preservation essential.

In Europe the stone-age came to an end by the introduction of bronze. This metal is an alloy of about nine parts of copper and one part of tin.† It melts and moulds well; the molten mass in cooling slowly acquires a tolerable degree of hardness, inferior to that of steel, it is true, but superior to that of very pure iron. We therefore understand how bronze would long be used for manufacturing cutting-instruments, weapons and numerous personal ornaments. The northern antiquaries have very properly called this second great phase in the development of European civilization the *bronze-age*.

The bronze articles of this period, with a few trifling exceptions, have not been produced by hammering, but have been regularly cast, often with a considerable degree of skill. Even the sword-blades were cast, and the hammer (of stone) was only used to impart a greater degree of hardness to the edge of the weapon.

The bronze-age has therefore witnessed a mining industry, which was completely wanting during the stone-age. Now the art of mining is so essential to civilization, that without it the world would perhaps yet be exclusively inhabited by savages.

* Flourens: *De la longévité humaine*. Paris, 1835, p. 127. "Man, from the construction of his teeth, his stomach, and his intestines, is primitively *frugivorous*, like the monkey. But the frugivorous diet is the most unfavorable, because it constrains its followers perpetually to abide in those countries which produce fruit at all seasons, consequently in warm climates. But, when once the art of cooking was introduced, and applied both to vegetable and animal productions, man could extend and vary the nature of his diet. Man has consequently two diets; the first is primitive, natural and *instinctive*, and by it he is *frugivorous*, the second is artificial, being due entirely to his intelligence, and by it he is *omnivorous*."

† Bronze is still used for casting bells, cannon, and certain portions of machinery. It must not be confounded with common brass, which is a compound of copper and zinc, much less hard, and appearing only in the iron-age.

It is then worth our while to enquire more closely into the origin of bronze.

Copper was not difficult to obtain. In the first place, virgin copper is not particularly scarce. Then, the different kinds of ore which contain copper combined with other elements, are either highly colored, or present a marked metallic appearance, and are consequently easily known; they are besides not hard to smelt, so as to separate the metal. Finally, copper-ore is not at all scarce; it is met with in the older geological series of most countries.

Virgin tin is unknown, but tin ore is heavy, of dark color and very easy to smelt. However frequent copper may be, tin is of rare occurence. Thus the only mines in Europe which produce tin at the present day are those of Cornwall in England, and of the Erzgebirge and Fichtelgebirge in Germany.

But the question arises, whether, previous to the discovery of bronze, man, owing to the great rarity of tin, may not have begun by using copper in a pure state. If so, there would have been a copper-age between the stone-age and the bronze-age.

In America this has been really the case. When discovered by the Spaniards, both the two centres of civilization, Mexico and Peru, had bronze, composed of copper and tin, and used it for manufacturing arms and cutting-instruments in the absence of iron and steel, which were unknown in the New World. But the admirable researches of Messrs. Squier and Davis in the antiquities of the Mississippi valley* have brought to light an ancient civilization of a remarkable nature, and distinguished by the use of raw virgin copper, worked in a cold state, by hammering, without the aid of fire. The reason of its being so worked lies in the nature of pure copper, which when melted flows sluggishly and is not very fit for casting. A peculiar characteristic of the metal, that of occasionally containing crystals of virgin silver, betrays its origin, and shows that it was brought from the neighborhood of Lake Superior. This region is still rich in metallic copper, of which single blocks, attaining a weight of fifty tons, have lately been discovered. There was even found at the bottom of an old mine a great mass of copper, which the ancients had evidently been unable to raise, and which they had abandoned, after having cut off the projecting parts with stone hatchets.†

The date of that American copper-age is unknown. All we know is, that it must reach at least as far back as ten centuries, that space of time being deemed necessary for the growth of the

* Squier and Davis: Ancient Monuments of the Mississippi Valley. Smithsonian Contributions to Knowledge; Washington, 1848. It is one of the most splendid archæological works ever published.

† Lapham: The Antiquities of Wisconsin. Smithsonian Contributions to Knowledge, 1855, p. 76.

virgin forests now flourishing upon the remains of that antique civilization, of which the modern Indians have not even retained a tradition.

It is finally worthy of remark, that the *mound-builders*, as the Americans call the race of the copper-age, seem to have immediately preceded and prepared the way for the Mexican civilization, destroyed by the Spaniards; for, in progressing southwards, a gradual transition is noticed from the ancient earthworks of the Mississippi valley to the more modern constructions of Mexico, as found by Cortez.

In Europe the remains of a copper-age are wanting. Here and there a solitary hatchet of pure copper is found. But this can be easily accounted for by the greater frequency of copper, while tin had usually to be brought from a greater distance, so that its supply was more precarious.

As Europe did not witness a regular development of a copper-age, it seems, according to Mr. Troyon's very just remark, that the art of manufacturing bronze was brought from another quarter of the world, where it had been previously invented. It was most probably some region in Asia, producing both copper and tin, where those two metals were first brought into artificial combination, and where also traces of a still earlier copper-age are likely to be found.

An apparently serious objection might be started here by raising the question, how mines could be worked without the aid of steel. This however is sufficiently explained by the fact, that the hardest rocks can be easily managed through the agency of fire. By lighting a large fire against a rock, the latter is rent and fissured, so as considerably to facilitate its quarrying. This method was frequently employed when wood was cheaper, and is even practised at the present day in the mines of the Rammelsberg in Germany, where it facilitates the working of a rock of extreme hardness.

That metal of dingy and sorry appearance, but more truly precious than gold or the diamond—iron—at length appears, giving a wonderful impulse to the progressive march of mankind, and characterising the third great phase in the development of European civilization, very properly called the *iron-age*.

Our planet never produces iron in its metallic or virgin state, for the simple reason, that it is too liable to oxydation. But among the aerolites there are some composed of pure iron with a little nickel, which alters neither the appearance nor sensibly the qualities of the metal. Thus the celebrated meteoric iron discovered by Pallas in Siberia was found by the neighboring blacksmiths to be malleable in a cold state.* Meteoric iron has even been

* Pallas: *Voyages en Russie*, Paris, 1793, iv, 595. There was but one mass of this meteoric iron; it weighed 1600 pounds.

worked by tribes to whom the use of common iron was unknown. Thus Amerigo Vespucci speaks of savages near the mouth of the La Plata, who had manufactured arrow-heads with iron derived from an aërolite.* Such cases are certainly of rare occurrence, but they are not without their importance, for they explain how man may probably have first become acquainted with iron, and they also account for the occasional traces of iron in tombs of the stone-age, if indeed this fact be well established.

It is notwithstanding evident, that the regular working of terrestrial iron-ore must have been a necessary condition of the commencement and progress of the iron-age.

Now, iron-ore is widely diffused in most countries, but it has usually the look of common stones, being distinguished more by its weight than its color. Moreover its smelting requires a much greater degree of heat than copper or tin, and this renders its production considerably more difficult than that of bronze.

But, even when iron had been obtained, what groping in the dark and how much accumulated experience did it not require, to bring forth at will bar-iron or steel! Chance, if chance there be, may have played a part in it. But as chance only favors those privileged mortals who combine a keen spirit of observation with serious meditation and with practical sense, the discovery was not less difficult or less meritorious. We need not then be surprised, if man arrived but tardily at the manufacture of iron and steel, which is still daily improving.

In Carinthia traces of a most primitive method of producing iron have been noticed. The process seems to have been as follows: on the declivity of a hill was dug an excavation, in which was lighted a large fire; when this began to subside, fragments of very pure ore (hydrous-oxyd) were thrown into it and covered by a new heap of wood. When all the fuel had been consumed, small lumps of iron would then be found among the ashes.† All blowing apparatus was in this manner dispensed with; an important fact when we come to consider how much the use of a blast complicates metallurgical operations, because it implies the application of mechanics. Thus certain tribes in Southern Africa, although manufacturing iron and working it tolerably well, have not achieved the construction of our common kitchen bellows, apparently so simple; they blow laboriously through a tube, or by means of a bladder affixed to it.

The Romans produced iron by the so-called Catalonian process, and the remains of Roman works of that description have been discovered and investigated in Upper Carniola in Austria.‡

* Smithsonian Contributions to Knowledge, vol. ii, art. 8, p. 178.

† Communicated to the author by mining engineers in Carinthia.

‡ *Jahrbuch der k. k. geologischen Reichsanstalt.* Wien, 1850, ii, 199. Carinthia and Upper Carniola formed part of the Roman province *Noricum*, celebrated for its iron.

The Catalonian forge is still used in the Pyrenees, where it yields tolerable results, but it consumes a large quantity of charcoal, requires much wind, and is only to be applied to pure ore, containing but a very small proportion of earthy matter producing scoriæ; for the process consists in a mere reduction with a soldering and welding together of the reduced particles, without the metal properly melting. According to the manner in which the operation is conducted, bar-iron or steel are obtained at will. This direct method dispenses with the intermediate production of cast iron, which was unknown to the ancients, and which is now the only means of producing iron on a great scale.

Silver accompanies the introduction of iron into Europe, at least in the northern parts, while gold was already known during the bronze-age. This is natural, for gold is generally found as a pure metal, while silver has usually to be extracted from different kinds of ore by more or less complicated metallurgical operations—for example, by cupellation.

With iron appear also for the first time in Europe, glass, coined money, that powerful agent of commerce, and finally the alphabet, which, as the money of intelligence, vastly increases the activity and circulation of thought,* and is sufficient of itself to characterize a new and wonderful era of progress. From thence can we date the dawn of history and of science, in particular of astronomy.

The fine arts also reveal, with the introduction of iron in Europe, a new and important element, indicating a striking advance. Already in the stone-age, but more in the bronze-age, the natural taste for art reveals itself in the ornaments bestowed upon pottery and metallic objects. These ornaments consist in dots, circles, and zigzag, spiral, and S-shaped lines, the style bearing a geometrical character, but showing pure taste and real beauty of its kind, although devoid of all delineations of animated objects, either in the shape of plants or animals. It is only with the iron-age that art, taking a higher range, rose to the representation of plants, animals, and even of the human frame. No wonder, then, if idols of the bronze-age, as well as of the stone-age, are wanting in Europe. It is to be presumed that the worship of fire, of the sun and of the moon, was prevalent in remote antiquity, at least during the bronze-age, perhaps also during the stone-age.

The preceding pages constitute a sketch, certainly very rough and imperfect, of the development of civilization. They establish however in a striking manner the fact of a progress, slow,

* "The circulation of ideas is for the mind what the circulation of specie is for commerce, a true source of wealth." C. V. de Bonstetten: *L'homme du Midi et l'homme du Nord.* Genève, 1826, p. 175.

but interrupted and immense, when the starting point is considered. The physical constitution of man has naturally benefitted by it. The details contained in the treatise, of which the present paper forms the introduction, prove that the human race has been gradually gaining in vigor and strength since the remotest antiquity.* The domestic races also, the dog first, then the horse, the ox, the sheep, have shared in this physical development. Even the vegetable soil has been gradually improving since the stone-age, at least in Denmark.

And yet there are persons who deny all general progress, seeing everywhere nothing but decay and ruin, like that worthy specimen of a northern pessimist, who exclaimed, "see how man is degenerated, he has even lost his likeness to the monkey!"

ART. III.—*On a new genus of Patelliform shells from the Cretaceous rocks of Nebraska;*† by F. B. MEEK and F. V. HAYDEN. (With a plate.)

Genus ANISOMYON, M. & H.

Etym. ἄνισος, unequal; μῦών, muscle; in allusion to the unsymmetrical muscular scar.

PLATE I.

Generic characters.—Shell very thin, patelliform, or obliquely conical, with an ovate, oval, or circular base; margins entire; surface nearly smooth, or only marked by obscure lines of growth, crossed on some species by fine radiating striæ; summit more or less elevated, located between the middle and the anterior end, sometimes nearly central,—immediate apex very small, and abruptly curved backwards, but not spiral; interior without a projecting lamina or other appendage. Muscular scar irregularly horse-shoe shaped, enlarged at the extremities, with the open part directed towards the shorter end of the shell; becoming abruptly attenuate, or broken into a row of minute oval or circular spots on the right posterior side;—anterior extremities connected by a slender line, which usually passes across just in front of the summit.

* This agrees perfectly with the testimony of statistics. See Quetelet, *Sur l'homme et le developpement de ses facultés.* Paris, 1835, ii, 271. This work of first-rate merit is very near akin to archæology. Mr. Quetelet has just published a new work which will certainly be even more remarkable than the first, and which the author of the present paper regrets not having had within his reach.

† The specimens belong chiefly to the collections brought from Nebraska by Lieut. G. K. Warren, U. S. Top. Eng. Full illustrations and descriptions of the species will appear in his report.

On the left side of the shell, the anterior extremity of the muscular impression (*a*, fig. 2 and 3, of Plate I.) is generally not so much enlarged as on the right, but sometimes extends slightly farther forward; posteriorly it passes around in the form of a a band to the middle of the slope behind (*b*, fig. 2 and 3), where it is abruptly enlarged and curves upwards. From this point to the larger anterior termination on the right side, there is usually only a slender line (*c*, fig. 2), which is not always quite connected with the enlarged extremity of the band-like part coming around from the left side. Generally this slender line is nearly or quite entire, while in other specimens, even of the same species, it is broken into a series of minute scars as seen at *c*, fig. 3, and in some instances it seems to be entirely obsolete, so as to leave the enlarged anterior extremity on the right, quite isolated.

In most instances, the specimens are found with the small apex (*d*, of fig. 1) broken or worn away, in which condition its former existence would scarcely be suspected. In at least one species (*A. borealis*) this small apex seems to be perforated in the end, the minute aperture being circular, and about large enough to fairly receive the point of a pin. This may be due to accident, but the thickened and smooth margin of this little opening, as seen under a magnifier, has very much the appearance of a natural orifice. We are not sure that this exists in the other species, but suspect it does. In two of the species *A. borealis*, and an undescribed form, there are six equidistant impressed hair lines radiating from the summit down the sides, nearly or quite to the margins, but as there are no traces of such lines on some of the others, presenting the same internal characters, we infer they can scarcely be regarded as a generic character.

From the foregoing description it will be seen that the group of shells we propose to include in this genus, although having the form of *Patella*, present striking differences in the unsymmetrical character of the muscular scar, indicating fundamental peculiarities in the structure of the animal, while they are all much thinner and smoother shells than we usually see in that genus. In some specimens, where there appears to be a complete break in the muscular scar on the right posterior side, there would seem to be some analogy to the genus *Siphonaria*, but as we observe no traces of a siphonal groove passing through this gap, nor any fold in the margin opposite it, and the slender portion of the muscular impression usually passes nearly or quite across, it is scarcely possible any organ such as exists in *Siphonaria*, could have been extruded there.

The more convex species, such as *A. borealis*, are somewhat similar externally to some species of *Hipponyx*, but to say noth-

FOSSIL SHELLS FROM NEBRASKA.

Am. Jour. Sci. V. XXIX. No. 85 Jany 1860. PLATE I.

Fig. 1.

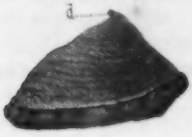


Fig. 2.

Fig. 3.

Lith by Sanderson & Collard, New Haven Ct.

Fig. 1 Anisomyon patelliformis side view.

Fig. 2 Dorsal view of same, with a portion of the shell removed so as to show the muscular scar on the internal cast.

Fig. 3 Internal cast of another specimen of same species, showing muscular scar.

ing of other differences, the fact that the open extremity of the horse-shoe shaped muscular scar in our shells is always turned towards the shorter end, or in other words, that the apex is placed in front of the middle instead of behind it, shows they have no affinities to that or any allied genus.

They would then seem to be perhaps more nearly related to *Acmæa* and *Gadinia* than to any other of our existing mollusca, since in both these genera the animal is more or less unsymmetrical, the former having the branchial plume exserted from the right side of the neck, and the latter a siphon occupying a groove on the right just in front of the anterior extremity of the muscular scar, which is shorter on that side than on the other. Our shells, however, differ from these genera in the peculiar attenuate or interrupted character of the muscular impression on the right posterior side, and the folding back of the apex.* In the thinness of the shell and the nature of the surface, they are most like *Acmæa*, with which we at first thought them probably identical, but adopting the opinion of M. d'Orbigny that this genus is synonymous with *Helcium* of Montfort, we referred them provisionally to the latter as the older name. Not long afterwards we observed the peculiar character of the muscular impression on an internal cast of one of the species, but at first supposed it merely due to some accident; subsequently however, we ascertained that it exists in five clearly distinct species, and cannot be regarded as an accidental or specific character.

It is probable many of the Cretaceous and Jurassic species that have been referred by different authors to the genera *Patella*, *Acmæa*, *Helcium*, &c., will be found to possess the internal characters of this genus. Judging from the figures of the Cretaceous and Jurassic species of patelliform shells we have seen in published works, specimens showing the muscular scar, have rarely been found. We have observed the characters of this genus in the following Nebraska species:—

ANISOMYON BOREALIS, (=*Hipponyx borealis*, Morton, 1842=*Helcium carinatum*, Meek & Hayden, 1856).
A. SEXSULCATUS, (=*Helcium sexsulcatum*, M. & H.).
A. ALVEOLUS, (=*Helcium alveolum*, M. & H.).
A. PATELLIFORMIS, (=*Helcium patelliforme*, M. & H.).
A. SUBOVATUS, (=*Helcium subovatum*, M. & H.).

Washington, D. C., Nov. 20, 1859.

* Dr. A. A. Gould, the well known conchologist of Boston, to whom we sent sketches of these shells, writes that he concurs with us in regarding them as being clearly distinct from all the recent genera to which such fossil forms are usually referred.

ART. IV.—*General account of the results of the discussion of the Declinometer observations made at Girard College, Philadelphia, between the years* 1840 *to* 1845, *with special reference to the eleven year period;* by A. D. BACHE, Superintendent of the U. S. Coast Survey.

[Communicated to the American Association for the Advancement of Science, by authority from the Treasury Department.]

IT is proposed to give here in outline the results of an investigation of the magnetic observations made with the declinometer, between the years 1840 to 1845, at the Girard College observatory, with special reference to the eleven year period in the amplitude of the solar-diurnal variation and the disturbances of the magnetic declination. Prof. Henry, Secretary of the Smithsonian Institution, has kindly offered to publish the memoir in full in the Smithsonian Contributions to Knowledge. It is my intention to pursue the discussion by taking up the investigation of the lunar influence on the same magnetic element.

In coöperation with the scheme adopted at the British Colonial Observatories, a series of magnetic and meteorological observations were made at the Girard College observatory with instruments purchased under the direction of the trustees of the College, the observations being made under the patronage of the American Philosophical Society, and finally completed for the use of the Topographical Bureau of the War Department. These observations were made under my direction and superintendence. The series commenced in May, 1840, and with short interruptions terminated in June, 1845, thus furnishing a five years series of magnetic observations taken bi-hourly up to Oct. 1843, and after that date hourly. The readings of each magnetic element were united into means, and were also presented graphically (in the fourth volume of the record). This was done under my direction by J. Ruth, Esq., but owing to other laborious duties the record could not be submitted to a more complete reduction. I have now resumed the subject by the assistance of Charles A. Schott, Esq., Assistant in the Coast Survey, by whom, under my immediate direction, and as my assistant in this special matter, the present paper has been prepared.*

Although other magnetic observatories furnish by their judicious geographical location, a basis for the generalization of their results, it is nevertheless desirable to obtain results from intermediate observatories as confirmations or as corrections. In the investigation of the disturbance-law at Point Barrow, when compared with the same at Toronto, a very remarkable mutual

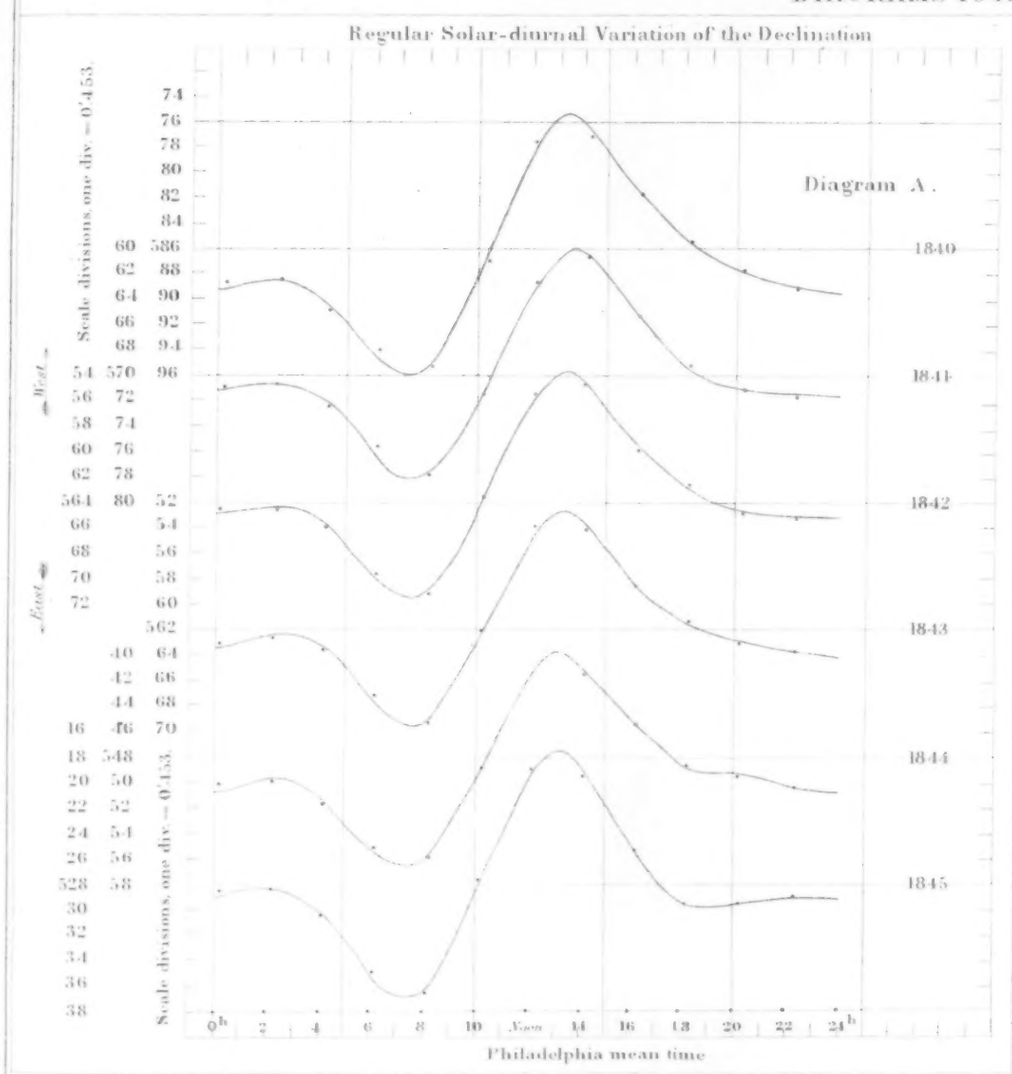
* It may be proper to state that this work has been performed out of Office hours, and at my own expense.

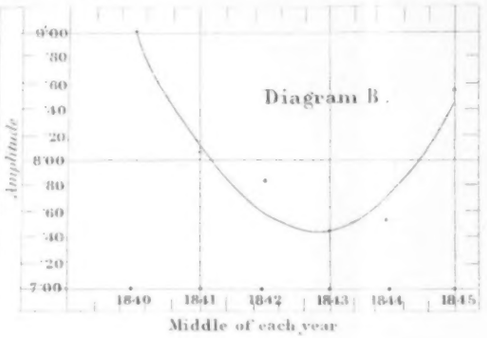
DISCUSSION OF THE MAGNETICAL AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE, PHILADELPHIA

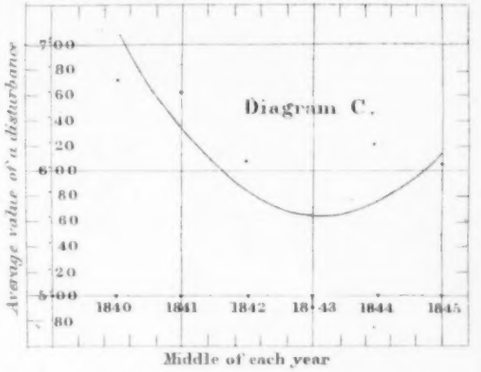
IN 1840, 41, 42, 43, 44 & 45

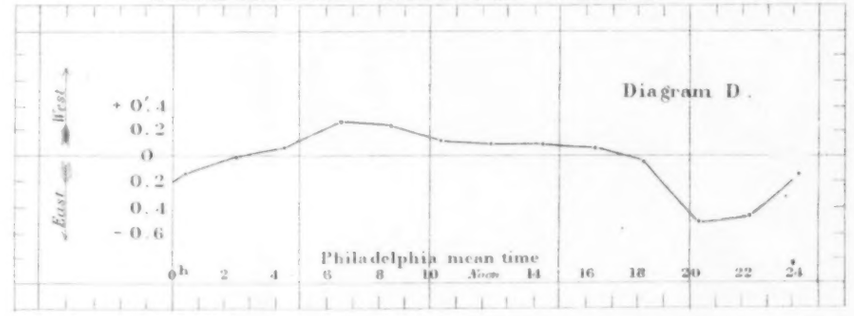
A.D.BACHE L.L.D. SUPERINTENDENT

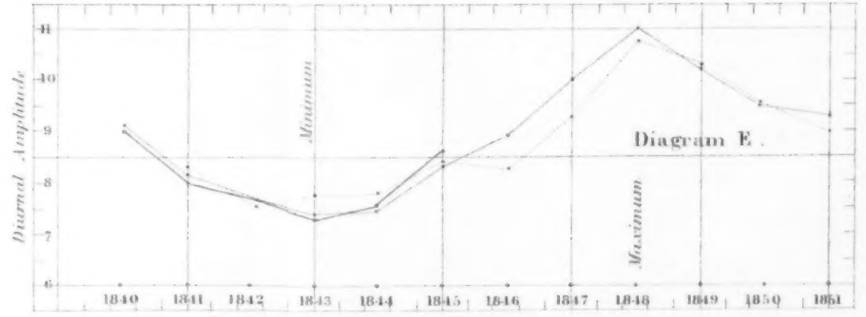
DIAGRAMS TO PART I. 1859.











relation of the law at these stations resulted from such a comparison, and farther examination may bring to light other dependencies of a mutual character.

According to the latest determination the position of the Girard College observatory is in latitude 39° 58′ 23″ (north), and in longitude 75° 10′ 05″=5^h 00^m 40^s·3 west of Greenwich. From it Toronto bears 38° 45′ west of north (true) and is distant about 334 statute miles.

It is proposed specially to investigate the law of the eleven year period, or, as it is more frequently called, the decennial period, there being yet an uncertainty as to its precise length. It is supposed to have some direct or indirect connection with the solar spot period, which correspondence, according to late investigations by Prof. R. Wolf, is so close as even to exhibit analogous disturbances. The following discussion will afford a contribution towards the determination of the epoch of the occurrence of a minimum in certain phases of the magnetic variation and disturbances, corresponding to a minimum of the solar spots. The method of reduction is substantially the same as that adopted by General Sabine. Earlier investigations of Dr. Lamont and those by Mr. Kreil differ from his in not including the discussion of the disturbances in connection with the period in question.

As long as the magnitude of the deflection remains the only criterion by which a disturbance may be recognized as such, the adoption of any limit of deviation from the normal value of the same hour, month and year, must necessarily remain in some measure arbitrary, or, in other words, there must always remain after the separation of the disturbances a certain small amount of their effect in the remaining regular diurnal progression. To effect the separation, Peirce's criterion has been used with entire success. After a preliminary investigation as to the number of disturbances separated, the limit, as pointed out by the criterion, or a deviation of 8 scale divisions (or 3′·6 of arc) has been adopted in the present discussion, as constituting a disturbed observation. Accordingly all observations differing by that amount or more from the mean monthly value of their respective hour were marked by a pencil line. Next a new hourly mean was taken, omitting values so marked, and each observation was again examined in reference to deviation from this new mean. This process was repeated when necessary, so that in all cases, values differing eight scale divisions or more from the mean were excluded. The last mean thus obtained for each observing hour and each month has been called "the normal." These values have been tabulated and are given for each month and year separately, together with such corrections as the omissions or interruptions demanded. The bi-hourly, and afterwards the hourly readings (and their means) were made 19½^m after the hour so as to correspond to an even Göttingen hour (diagram A).

For the purpose of comparing the annual means of the normals, or the mean march of the regular solar diurnal variation for each year, the results have been expressed analytically by means of Bessel's formula, and by the application of the method of least squares.

Probably owing to the several accidental changes in the suspension of the bar, and consequent uncertainty in the precise amount of scale correction, the mean readings of each year, when compared with one another, exhibit differences not actually due to irregularities occasioned by declination changes. Though this question does not directly bear upon the present investigation, which mainly depends on differences of readings, it will be proper to remark that the observed increase, giving the weight $\frac{1}{2}$ to the mean of 1840 and 1845 (on account of incomplete record) is under the supposition of a uniform annual change between these years, equal to 4′·50. According to Mr. Schott's latest investigation of the secular change of the declination in Philadelphia supported by observations between the years 1701 and 1855·7, the annual increase between the years 1840 to 1845 is 4′·98, a result which accords tolerably well with actual observations. According to this formula the declination on the 1st of January, 1843, the mean epoch of the present series, is 3° 32′ West with a probable error of ±10′. This declination corresponds to the scale reading 560·31, which has been deduced by taking into account the weights of the annual means.

The expressions have been thrown into curves (diagram B), and the agreement between computed and observed values is shown by the introduction of dots giving the observed reading. The probable error of any single representation is ±0′·1. By means of the formulæ the following values were computed.

For	Epoch of maximum eastern deflection.	Correspond. scale reading	Epoch of maximum western deflection.	Correspond. scale reading.	Amplitude (in arc.)
	h m	d	h m	d	′
1840	7 26 A. M.	595·67	1 34 P. M.	575·71	9·08
1841	7 49	577·96	1 49	560·21	8·06
1842	7 36	571·24	1 37	553·96	7·83
1843	7 40	569·54	1 24	553·06	7·46m
1844	7 32	556·50	1 18	539·99	7·51
1845	7 34	536·65	1 16	517·81	8·53
Mean	7 36 A. M. ± 3m		1 30 P. M. ± 4m		

The inequality constituting the ten or eleven year period is plainly exhibited in the last column, the progression of the numbers being quite regular; the year 1843 is directly indicated as the year of the minimum range of the diurnal fluctuation. By means of a special formula, deduced by least squares, and

representing a single value within $\pm 0'.11$, the month of May, 1843, is indicated as the epoch of minimum amplitude.

The discussion of the disturbances, as far as they bear on the decennial inequality, next follows, taking in also some collateral results.

The total number of observations for changes of declination recorded and discussed amount to 24,566; of these, according to the preceding investigation, 2,357 were separated as disturbances. There is one disturbed observation in every 10·4 observations. The discussion of the disturbances is divided into two parts, that of the number, and that of the amount of the deflections. Omissions in the record have been supplied by the use of proper ratios showing the law as given by the full periods, and interpolated values are enclosed within brackets. The number of disturbances in each month of the year or the annual inequality in the distribution of the disturbances has been made out for each year, and the means and ratios are also given. The principal maximum occurs in October (at Toronto in September), the secondary in April; the two minima, nearly equal in amount, occur in February and June (the first one in January at Toronto). The ratios of the number of monthly disturbances to the average number are given in the following table, showing the same also divided into westerly and easterly values.

RATIOS.				RATIOS.			
	W.	E.	Total.		W.	E.	Total.
January,	1·27	0·42	0·77	July,	0·58	1·18	0·86
February,	0·70	0·46	0·52m	August,	2·00M	1·14	1·59M
March,	0·83	0·57	0·68	September,	0·93	1·86	1·36
April,	0·95	0·80	$0·91M_2$	October,	1·58	2·50M	2·12M
May,	0·55	0·60	0·58	November,	0·96	1·12	1·08
June,	0·44	0·61	0·53m	December,	1·21	0·74	1·00
				Mean,	1·00	1·00	1·00

The ratios show a general correspondence in the numbers of westerly and easterly deflections; the westerly seem to occur most frequently in August, while the easterly predominate in October; the secondary maximum of both series is in April. For the total number the minima occur in February and June. The following table contains the number of disturbances in each year.

1840	483	weight $\frac{1}{2}$
1841	539	
1842	446	
1843	275	weight $\frac{2}{3}$
1844	308	
1845	264	weight $\frac{1}{2}$

Proportional number of western disturbance 937, of eastern 912; at Toronto the eastern predominate over the western in the proportion of 1·17 to 1.

These numbers do not indicate the law of the eleven year period as plainly and systematically as found by the investigation

of the diurnal amplitude, yet giving proper weight, (on account of deficiencies,) the minimum number of disturbances falls in the year 1843.

If we distribute the disturbances, 1,942 in number for the even hours, according to their respective hours of occurrence, we find the following ratios:

Philadelphia mean time.	RATIOS. W.	RATIOS. E.	Total number.
h m			
0 (19½)	0·82	1·20	162
2 "	1·18	1·16	189M
4 "	1·08	0·96	168
6 "	1·35	0·80	173
8 "	1·29	0·70	161
10 "	1·32	0·88	178
Noon "	1·13	0·71	150
14 "	0·95	0·67	133m
16 "	1·07	0·73	148
18 "	0·87	0·90	143
20 "	0·40m	1·66M	167
22 (19½)	0·54	1·58	170

The numbers in each column show a regular progression; the disturbances, irrespective of their direction, have a minimum at 2 P. M., and a maximum at 2 A. M., (at Toronto the respective hours are 2 P. M. and 22 P. M.). The principal contrast is between the hours of the day and the hours of the night. In the table given above the most striking result is that the westerly disturbances have their minimum precisely at the hour (8 P. M.) when the easterly have their maximum, and the exact coincidence of this result with that deduced by General Sabine for Toronto is not less remarkable. In connection with this subject, it may be remarked that the same distinguished magnetist found a singular mutual relation to subsist between the phenomena at Toronto and Point Barrow, on the shores of the Arctic sea,—the laws of the easterly deflection at one station being found to correspond at the same local hours with those of the westerly deflections at the other station, and vice versa. This contrast therefore holds good for Philadelphia as well as Toronto.

If we classify the disturbances according to their amount, we obtain the total aggregate and mean values of a single disturbance in the different years as follows:

	Aggregate amount in scale divisions.	Mean value.	Mean value. W.	Mean value. E.
	d	*t*	*t*	*t*
1840	7155·5	6·70	6·52	7·20
1841	7844·4	6·61	5·93	7·07
1842	6019·1	6·11	5·53	6·70
1843	2932·2	4·85	4·85	4·85
1844	4227·3	6·21	6·21	6·21
1845	3521·4	6·02	5·25	6·84

The eleven year period is well marked in the aggregate as well as in the mean values, and the precise epoch of the minimum was found by a special formula. It took place in August, 1843, and as a resulting epoch from this and the previous determination, June, 1843 may be adopted. This is graphically represented on diagram C.

The following table gives the ratios of the aggregate amount of disturbances in each month of the year:

	Total.	W.	E.		Total.	W.	E.
January,	0·72	1·21	0·33	July,	0·87	0·46	1·29
February,	$0·54m_2$	0·59	0·46	August,	1·61	1·95	1·28
March,	0·66	0·73	0·56	September,	1·56	0·99	2·12
April,	$0·94M_2$	1·04	0·84	October,	$2·06M_1$	1·67	2·46
May,	0·56	0·52	0·56	November,	1·06	1·09	1·02
June,	$0·42m_1$	0·37	0·47	December,	1·00	1·38	0·61

In reference to the first column, the maximum amount of disturbances occurs in October (at Toronto in September); the minimum in June (as at Toronto); the secondary maximum occurs in April (the same at Toronto); the secondary minimum occurs in February (and at Toronto in January). If separated into east and west deflections, maxima occur in September (mean of August and October) and April; and minima in June and January (same as at Toronto).

The arrangement according to the hours of the day gives the following ratios, to which is added, in the last column, the diurnal disturbance variation obtained by dividing the excess of aggregate westerly over easterly values by the total number of days of observation.

Philadelphia mean time.	RATIOS.			Disturbance, variation in arc.
	W.	E.	Both combined.	
h m				′
0 ($19\frac{1}{2}$)	0·83	1·24	1·04	−0·16
2 "	1·16	1·10	1·13	−0·01
4 "	1·16	0·92	1·04	+0·05
6 "	1·46	0·67	1·06	+0·24
8 "	1·39	0·67	1·02	+0·22
10 "	1·22	0·77	0·99	+0·13
Noon "	1·03	0·63	0·83	+0·11
14 "	0·98	0·63	0·80m	+0·10
16 "	0·99	0·72	0·85	+0·07
18 "	0·84	0·89	0·84	−0·02
20 "	0·38m	1·88M	1·15	−0·53
22 ($19\frac{1}{2}$)	0·56	1·88	1·25M	−0·47

If we compare these ratios with the corresponding numbers in a preceding table showing the bi-hourly distribution in regard to number, we find, irrespective of the direction of the deflections, the 2 P. M. minimum preserved. The maximum is earlier and occurs at 10 P. M. (At Toronto these hours are respectively 1 P. M. and 9 P. M.) At Philadelphia as well as at Toronto the

ratios are nearly invariable from 10 A. M. to 6 P. M., and again from 8 P. M. to 8 A. M. The easterly maximum and westerly minimum at 8 P. M. form again a marked feature.

The law governing the disturbances during a solar day is clearly shown, and is of a systematic character. The diurnal variation caused by the disturbances, if superposed on the regular diurnal variation, would produce what is known by the name "mean diurnal variation." If we plot the disturbance curve on the same scale, or actually superpose it on the curves of the regular diurnal variation, it would hardly show to the eye, and the compound curve of the mean variation would keep within the maximum distance of a dot from the regular curve in the diagram (D). The disturbance variation has but one maximum and one minimum. Its most prominent feature is the easterly deflection at 8 o'clock ($+19\frac{1}{2}^m$) P. M. (at Toronto it is at 9 P. M.); the maximum deflection amounts at that hour to 32″ of arc, and to 45″ at Toronto. The greatest westerly deflection occurs at 6^h ($19\frac{1}{2}^m$) A. M. and amounts to but 14″ (at Toronto the hour is 8 A. M. with 6″, and from a five years series of observation, with 31″ of deflection). The range of the disturbance variation equals 46″. From 3 in the morning till 5 in the afternoon, the mean effect of the disturbances is to deflect the north end of the magnet to the west, and during the remaining hours (principally night hours) to the east. The westerly and easterly disturbance deflections, during a day, balance within 0′·02.

The annual inequality in the amplitude of the diurnal disturbance variation cannot satisfactorily be shown on account of the short and partly interrupted series of observations.

It is my intention to continue the discussion of the observations made at the Girard College Observatory.

After the above was written No. 1185 of the Astronomische Nachrichten came to hand, containing Prof. R. Wolf's interesting results on the close connection of the variation in the frequency of the solar spots, and the corresponding inequality in the amplitude of the diurnal variation of the declination. He deduces for Munich the simple formula, $\beta = 6'{\cdot}273 + 0'{\cdot}051\alpha$, where α represents a relative number expressive of the frequency of the solar spots, directly derived from observation, and β the amplitude of the diurnal variation. He found a close correspondence between these phenomena, showing the observed and computed amplitude for the Munich observations between 1835 and 1850. The average length of the solar spot period is reaffirmed to be 11·11 years $\pm$ 0·04 years. For Philadelphia we obtain $\beta = 7'{\cdot}080 + 0'{\cdot}039\alpha$, which formula represents the observations as follows:

Year.	a From solar spot observations.	Amplitude derived from a.	Observed amplitude.	Difference.
		′	′	′
1840	51·8	9·10	9·08	−0·02
1841	29·5	8·23	8·06	−0·17
1842	19·2	7·83	7·83	0·00
1843	8·4	7·41	7·46	+0·05
1844	12·2	7·55	7·51	−0·04
1845	32·4	8·34	8·53	+0·19

The correspondence between the observed diurnal amplitude and the same computed from observations of the solar spots is further exhibited in the annexed diagram (E). The dotted curve is the approximate Toronto curve from observation specially introduced to show the agreement at the epoch of the maximum in 1848. By computation from the solar spot observations, the amplitude at that time would amount to 11′·00, the whole range of the inequality of the diurnal variation would therefore be 11′·00−7′·46=3′·54.

It is much to be desired that this interesting branch of physical enquiry be further studied, as it forms one of the links connecting terrestrial with cosmical phenomena.

ART. V.—*A Visual Method of effecting a Precise Automatic Comparison of Time between distant stations;* by JONATHAN HOMER LANE. (With a plate.)

THE visual apparatus of which I here give a general description was invented several years ago, and is intended to supply the place, under certain circumstances, of the electric telegraph, in the determination of differences of longitude. Although the wires of the electric telegraph, when suspended in the air, appear to leave nothing to be desired, at least for distances of a few hundred miles, in situations where they are available, yet it has appeared to me that the visual method I propose may prove useful in many cases where the stations to be compared, particularly the astronomical stations in a trigonometrical survey, are removed to considerable distances from lines of electric telegraph. In those situations, also, where submarine or subterranean lines take the place of air lines, the visual method, on account of the comparatively slow velocity of the electric signal along the wires of such lines, and the open and irresolvable question whether the signal time might not be greater in one direction than the other, would be capable of furnishing a useful check upon the indications of the electric telegraph.

The general features of the method are the following:

First, an intense light shown at one station, A, and viewed at the other station, B, as a star.

Secondly, a uniform automatic movement at A, made to interrupt the light at regular minute periods of say one sixteenth of a second from the middle of one interruption to the middle of the next.

Thirdly, a uniform automatic movement at B, by which the star of light is made optically to travel around a circle at the rate of one revolution in the same period of one sixteenth of a second, the consequence of which is that the periodical interruption becomes visible to the eye as a break in the luminous circle produced by the motion of the star, and according as such break is seen upon one part or another of the circumference of the luminous circle, the relation of the movement at A to that at B becomes, inside of the recurring period of one sixteenth of a second, known in like manner as if they had been connected by a coupling shaft extended from one to the other.

Fourthly, a supplementary flash of the light at A, occurring at each whole second and during the interval of one of the interruptions before mentioned, which supplementary flash finds itself subject, in the movement at B, to an action by which it would be carried optically around a circle once only in one whole second, and by the position at which it occurs on the circumference of that circle indicates the sixteenths of the whole second. Also, a still further signal, by which account may be taken of the whole seconds, in ways too obvious to require special notice, and which will complete the knowledge of the relation of the movements at A and B to each other, or of the quantity by which one may be in advance of the other in its motion.

Fifthly, any of the known methods of effecting automatic comparison of the movement at either station with the clock at that station, by which means the comparison of the clocks at the two stations will be made to the minutest fraction of a second. Or, a single clock may be used, say at A, and any observation at B can by known methods be automatically referred to the movement at that station, and thus compared at once with the clock at A.

Further, if the automatic movement at B, besides giving optical motion to the star of light shown from A, is simultaneously made to produce periodical interruption of another intense light shown at B and seen at a third station, C, provided with a movement like that at B, the comparison from A to B may be extended directly onward from B to C, and from C onward to a fourth station, and so on, and such is the degree of precision which seems, so far as we can judge without direct experiment, attainable in the comparison between contiguous stations, that the probable error of a single comparison between the extremes of a line of twenty stations may, I believe, be made smaller than the hundredth part of a second.

Station A.

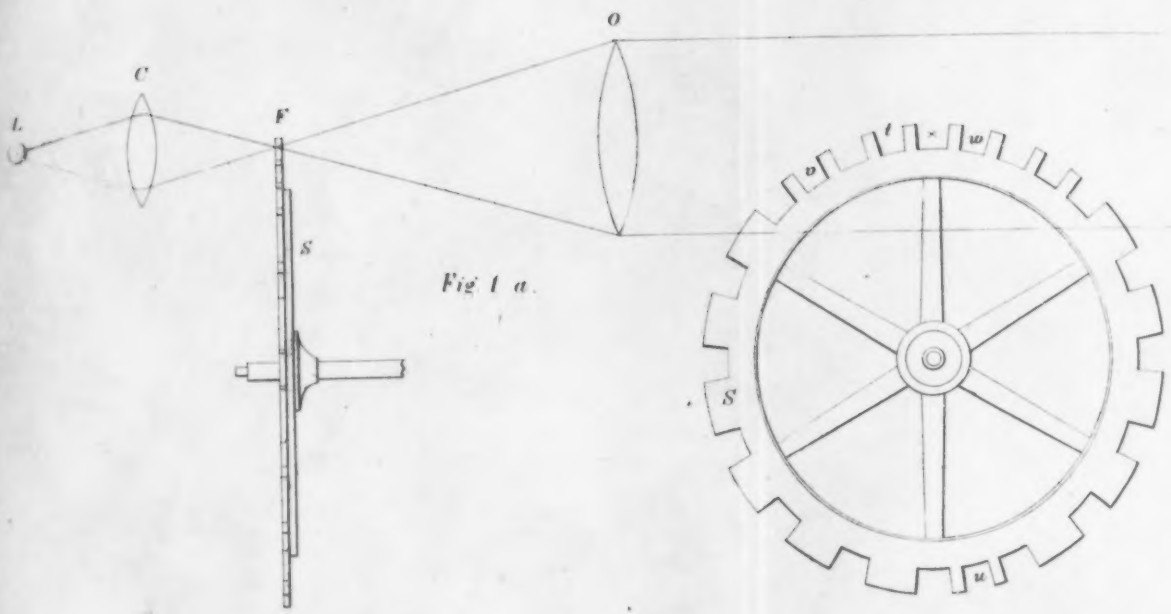


Fig. 1 a.

Fig. 2 a

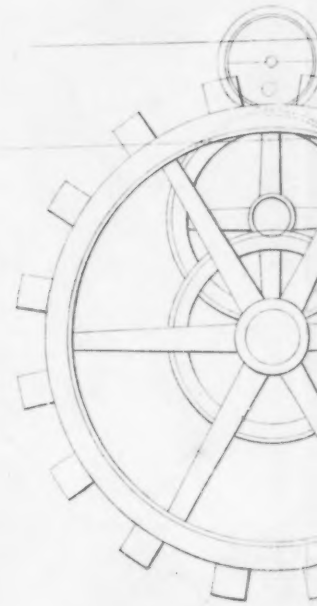


Fig. 2 b

J. H. LANE'S APPARATUS for a visual method of effecting a precise automatic comparison of time between distant Stations.

Lith. by Endicott & Ormand, New Haven, Ct.

Station B.

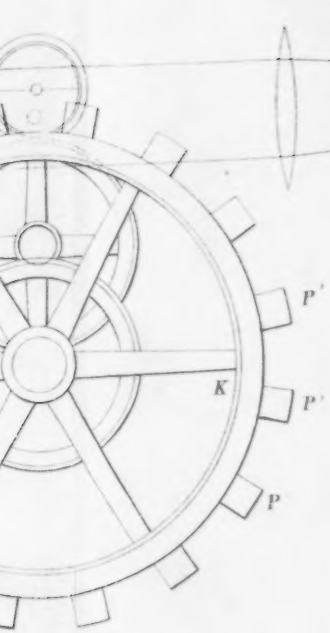


Fig 2 b

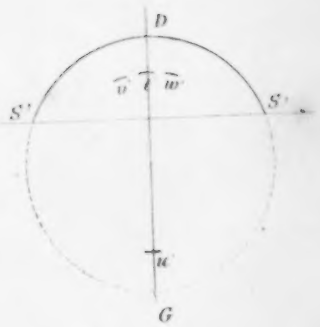


Fig. 3.

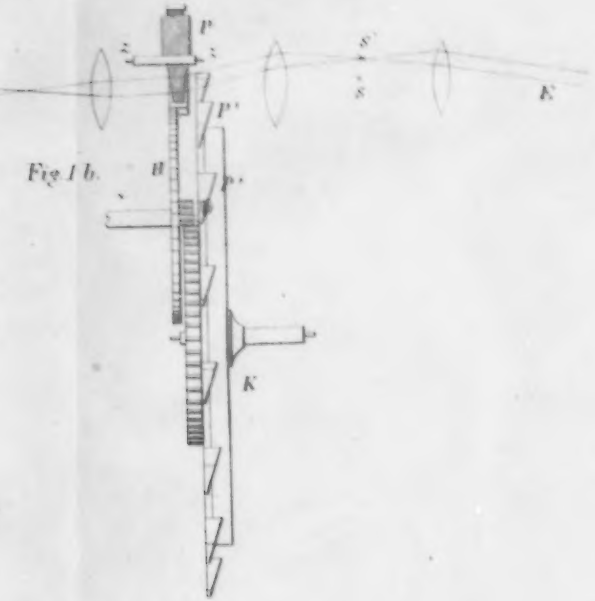


Fig 1 b.

An arrangement suitable for carrying the above plan into effect is illustrated by a sketch in the accompanying plate. At the station A, the rays of the signal light, diverging from their source L (Plate II, fig. 1, *a*), are converged by a lens C so as to meet and cross each other in the focus F of a telescope. Diverging from this point they traverse the object glass O, and issue from it in a nearly parallel beam directed to the station B. The light thus transmitted is periodically intercepted at the focus F by the projecting teeth of a rotating disc, or signal wheel, S, which is made to rotate uniformly at the rate of one revolution in about one second.

The telescope used at the station B for viewing the light shown at A, is furnished with a terrestrial eye-piece, and at that point where occurs the first image of the object glass, or crossing of all pencils of light that can pass through the telescope, is introduced a refracting glass prism P, shown in section in Fig. 1, *b*. The pencil formed by the light from A, on traversing the refracting prism, is turned aside so that the star image, which otherwise would be formed at *s*, is formed at *s'*, and the displacement is observed by the eye at E. Since this displacement is always in a plane at right angles to the edge of the refracting angle of the prism, if the latter be made to rotate on an axis *zz*, parallel to the axis of the telescope, the displaced star image *s'* will travel in a circle around *s* as a center. If the period of revolution be shorter than the duration of the luminous impression on the eye, and the light be unintermitting, the circle described by *s'* will appear to the eye as a continuous circle of light. The period of one sixteenth of a second may perhaps be taken as sufficiently small for continuity of luminous impression. Accordingly, if the prism be made to revolve about sixteen times per second, and precisely sixteen times during each revolution of the signal wheel S, and if the primary division of the latter be made by sixteen equidistant slotted openings in its border, then the luminous circle, which but for the interposition of the signal wheel would appear continuous and entire, will be seen in part obliterated, as shown in Fig. 3, the luminous part S' D S' having the same ratio to the obliterated part S' G S', that the width of one of the slotted openings of the signal wheel has to the width of a tooth. And as the luminous arc S' D S' appears on one part or another of the circumference, its angle of position, which may be observed by bringing the wire of a position micrometer into coincidence with the extremities of the arc, will determine the angle of position at which the prism arrives simultaneously with the arrival of the signal wheel at a given point of reference.

But for counting the whole sixteenths of a second it will be required to know also the simultaneous angle of position of a

wheel geared with the prism P so as to revolve only once in the time of one revolution of the signal wheel. The circular prismatic piece is of a diameter many times greater than that of the pencil of light, and the latter traverses the former at its border. Around the prismatic piece is fastened a toothed ring, into which gears the driving wheel H from which the prism takes its motion. Between this wheel H and the regulator from which it derives its uniform motion, is interposed a satellite wheel arrangement, by means of which the observer, without disturbing the invariable velocity of the regulator, can set the wheel H, and the parts to which it gives motion, forward or back in their course, and then allow them to proceed *at once* with the same correct velocity as before. In this way the observer will have absolute control of the angle of position of the luminous arc S′ D S′, and it may be agreed that as this angle of position slowly changes in consequence of the want of *perfect* unison between the movements at the two stations, he shall, from time to time, bring the luminous arc back to near coincidence with a standard position, that for instance which is shown in Fig. 3, the exact angle of position to be measured, however, in the manner above mentioned. Provided, then, the arc be not allowed to stray far from its standard position, it will be obvious that one part of the border of the prismatic piece P will never be traversed by the light which passes the sixteen primary openings of the signal wheel and forms that arc. The part thus unused is made with parallel faces, as shown in the figure, and then any supplementary flash of light occurring midway between the primary ones, will pass through the parallel part of P unrefracted, and may be refracted by a second prism P′, that moment interposed. This second prism is made to revolve once in the period of the sixteen revolutions of P, and in the best mode of construction that occurs to me is one of sixteen prismatic pieces P′, P′, P′, &c., so cut out, and attached to the border of a wheel or disc K, made to revolve in that period, that the edges of the refracting angles of all of them shall be parallel to each other, the whole forming the equivalent of a single prism cut into a large toothed wheel. This wheel K, like P, takes its motion from H, and is so geared that during all the intervals of time in which a passing pencil would encounter the refracting part of P, it will have free passage through one of the spaces between the pieces P′, P′, P′, &c., which, during the alternate intervals of time, will in their turn be interposed in the path of the pencil. Any flash of light, therefore, that escapes through any supplementary opening, as *t*, in the middle of one of the sixteen primary teeth of the signal wheel, will, in traversing the telescope at B, be refracted by one of the prisms P′ alone, and not by P. And if it be recollected that the several prisms P′ are in effect parts of one prism, as dis-

tinctly indicated in fig. 1, *b*, and that the action of this differs in no respect from that of P except in its longer period of revolution, and that this period of revolution is the same with that of the signal wheel, it will be obvious that if several supplementary openings be made in the signal wheel, as for instance two, *t* and *u*, in two teeth diametrically opposite to each other, and two others, *v* and *w*, in teeth adjacent to one of these on each side of it, the flashes of light through these openings will be seen by the eye at E to occur at points *t'*, *u'*, *v'*, *w'*, fig. 3, distributed around the circumference of a circle concentric with S′ D S′ G, and at angular intervals from each other identical with those between the corresponding openings in the signal wheel. It will be further obvious that the observed angle of position of the diameter *u' t'* will depend on the angle of position of the wheel K relatively to that of the signal wheel. The diameter *u' t'* becomes, then, by aid of the more exact indication of S′ D S′, an index by which we know the required angle of position at which the wheel K arrives simultaneously with the arrival of the signal wheel S at a given point of reference. As the most convenient mode of procedure in practice, the observer at B may operate the satellite wheel until the index diameter *u' t'* is brought to a position, for instance the vertical one in the figure, made to denote zero, and the position micrometer for taking the angle of position of S′ D S′ may be graduated to thousandths and ten thousandths of a second.

Instead of the above described arrangement there is a modification of it which I am disposed to prefer, the type of which is a pair of telescopes at station B, placed side by side so that one may contain the rapidly revolving prism and the other the more slowly revolving one, each prism being in this case unintermitting in its action, and the supplementary openings of the signal wheel being replaced by the filling up of a single one of the primary openings. The omission of the flash of light from this one would be observable through the slow prism and give the required indication, while it would not probably injure in any material degree the distinctness of the arc of light seen through the fast prism. Instead of a pair of complete telescopes, the equivalent of a pair of eye-pieces with a sliding object-glass to alternate between them at pleasure, would answer the same purpose. In this arrangement no rectification of the prisms by the observer would be necessary, it being always possible to observe the total deviation. This would be a great advantage on a line of very numerous stations, in which case it would, on the first described plan, be a somewhat critical matter to bring all the instruments on the line into the required correspondence for simultaneous observation.

As before intimated, it would be possible to employ but a single clock on the whole line of stations, but as this would require signal observations for every time observation at any other than the clock station, it would be more convenient to employ a clock at every astronomical station.

The question of the feasibility of the process described in this paper will depend primarily on the practicability of securing, with telescopes of moderate aperture, a sufficiency of light for such distances as from fifty to eighty miles, and next on the attainment of sufficient precision of rate in the uniform motion employed. I do not anticipate serious difficulty in either of these things. For the uniform motion, considering especially the light work it will have to do, the Fraunhofer regulator would I presume be everything that is required, or an electromagnetic regulator, similar to that described by me in a paper presented to the American Association at their meeting at Montreal, may be used if found reliable. From what a scientific friend has told me of his experience with distant lights, I think we are justified in anticipating the easy attainment of sufficiency of light.

A similar optical means can also be used for comparing a mean time clock at one station with a sidereal clock at another, by the method of coincidences, without other mechanism than the clocks themselves, though with diminished power of precision on a long line of stations. The pendulum of the one clock is made to carry in the focus of the telescope at its station, an opaque disc with a narrow slit, through which, at each oscillation, a flash of light is allowed to escape to the other station, and through the focus of the telescope at that station oscillates a wire carried by the pendulum of the other clock, which eclipses the flash of light at each coincidence of the two pendulums. Or the pendulum at the observing station may carry a mirror, in which either a flash or an interruption of light from the other station may be observed by reflection, and the coincidence noted when the flash or the break is seen at the same point of the field of view where it is observed with the pendulum at rest.

I have already observed that the visual method proposed in this paper might prove useful as a check, at least, upon the indications of submarine or subterranean lines of electric telegraph. But it seems less liable to uncertainty in its indications than even the air lines, the signals of which occupy a very appreciable and more or less ambiguous time in passing, and therefore on very extensive surveys it would be very instructive at least, and might be found to give increased accuracy, to add to the comparisons made by the telegraph wires, further comparisons by means of a sufficient number of the visual instruments to reach across the whole extent of the survey. In case it should

ever be undertaken, as has been proposed, to measure an extensive arc of the equator, the idea of such a visual method for the accurate determination of the differences of longitude, would be well worth considering.

I will close by suggesting one more obvious application of the method, and that is, the determination of the velocity of light, which, with a sufficiently high velocity of revolution of the prism and signal wheel, might be done with considerable accuracy by transmitting, in the same manner as before described from a second station to a third, a return signal from the second station to the first.

ART. VI.—*On Osmious Acid, and the position of Osmium in the list of Elements;* by J. W. MALLET, Prof. of Chemistry, &c., Univ. of Alabama.

IN most chemical text-books it is stated, on the authority of Berzelius, that there are five oxyds of osmium—OsO, Os_2O_3, OsO_2, OsO_3, and OsO_5—of which however the second and fourth have not been isolated, although compounds containing them are known. To these may be added a blue substance, first obtained by Vauquelin and supposed by Berzelius to consist of OsO united to either Os_2O_3 or OsO_2, and the highest oxyd, probably OsO_5, the existence of which was announced by Frémy in 1854.

While preparing osmium from some black platinum residues I have accidentally obtained, a substance which there is some reason to believe may be osmious acid—the hitherto unisolated teroxyd—mixed indeed with osmic acid, but still permitting certain of its properties to be observed.

Three or four ounces of the platinum residue were treated by a modification of the original process of Wollaston, now seldom adopted. The powder was mixed with three times its weight of nitre, the mixture was fused for some time in an iron crucible, and then poured out upon an iron plate. While still warm the fused cake was broken into fragments and put into a flask fitted with a cork, through which passed a tube two feet long, bent at right angles, and a funnel-tube, the latter drawn out to a very small bore at the lower end, and reaching to the bottom of the flask. The bent tube was well cooled, and *undiluted* oil of vitriol was very cautiously poured, by a few drops at a time, into the funnel.

The acid produced intense heat on coming in contact with the cake of potash salt, and oily drops of a bright *yellow* color began to make their appearance in the cooled tube. These drops very slowly congealed to a solid resembling unbleached bees-wax.

By the time the sulphuric acid had been added in slight excess a considerable quantity of this yellow substance had collected in the tube and in a receiver attached. By gentle heating the whole was obtained in the receiver, and united under a little water to a single mass. Towards the end of the distillation *colorless* needles and fused drops of the well known osmic acid came over, and doubtless a considerable portion of the yellow mass in the receiver consisted of the same.

At first it seemed probable that the yellow color of the latter was due merely to some impurity, and it was therefore cautiously resublimed, but it again collected of the same tint as before. It appeared to be even more fusible and volatile than osmic acid; it took a long time to congeal under a stream of cold water flowing over the outside of a tube in which it had been melted.

The water in which it was fused acquired a bright yellow color, and gave off fumes, the odor of which seemed to me somewhat different from that of osmic acid, and which irritated the eyes so insufferably that it was scarcely possible to finish work with the acid and put it up for preservation. It was removed as a single cake from the water, and sealed up hermetically in a glass tube which had been previously cleansed with care from all traces of dust or other organic matter. The water in which it had been fused was mixed with caustic potash, and gave a solution of very dark brown-red color, such a tint as would probably result from a mixture of the red* *osmite* of potash discovered by Frémy with the orange-brown *osmiate* of potash.

The sealed tube containing the fused cake or stick of yellow acid was allowed to remain upon a table exposed to the direct rays of the sun. The acid immediately began to sublime upon the sides of the tube, not in long needles and prismatic crystals like osmic acid (which seems to be monoclinic), but in feathery crusts like sal-ammoniac, which under a lens had somewhat the appearance of minute octahedrons grouped together. The color was still bright yellow, but in a short time the sublimed acid began to turn black, and in twenty-four hours the whole inner surface of the tube was perfectly black and opaque. A tube containing pure colorless osmic acid has been exposed in a similar way to the sun for three weeks without any such blackening taking place. A tube closed by a cork, or one from which dust has not been carefully removed will often cause osmic acid to turn dark, but never exhibits anything like the absolute blackness and opacity of the whole tube noticed in the present instance.

* A rose-red color is also characteristic of the salt supposed by Berzelius to be the ammonio-*terchlorid* of osmium, corresponding in the chlorine series to *osmite* of ammonia.

It is easy however to imagine the cause of this change undergone by the yellow acid if it be in fact the teroxyd of osmium (mixed with osmic acid). The teroxyd probably broke up into osmic acid and one of the lower oxyds of osmium or perhaps the metal itself. We might have

$$2OsO_3 = OsO_4 + OsO_2$$
$$5OsO_3 = 3OsO_4 + Os_2O_3$$
$$3OsO_3 = 2OsO_4 + OsO,$$

or,
$$4OsO_3 = 3OsO_4 + Os.$$

In order to ascertain, if possible, which of the above changes had taken place, the tube was opened two or three months after it had been sealed, and the contents were examined. The fused stick of acid was found to be black and partially friable; on heating in another glass vessel most of it sublimed, leaving a little black powder behind, and condensed in needles, still slightly yellowish, but differing little in appearance from common osmic acid. The inner surface of the original tube was found coated with a thin filmy, adherent crust, of a black color and considerable lustre. This was scraped off, and a portion of it gently heated in a stream of dry carbonic acid gas until all traces of adherent osmic acid were driven off. After cooling, the carbonic acid was replaced by dry hydrogen, and heat was again applied. Water condensed on the tube beyond the heated part, thus proving that an oxyd of osmium, not the metal, was under examination. Replacing again the hydrogen by oxygen, osmic acid was produced and carried off with the stream of gas. The black powder scraped off from the original tube was heated with hydrochloric acid, and seemed to be but slowly acted on; the acid however assumed a green color, and hence it is probable that the osmium existed as protoxyd.

It is not easy to see, without further investigation, how osmious acid could have replaced in part osmic acid in the attempt to prepare the latter as above described. Is there a particular stage of the decomposition of nitre by heat at which osmium may replace nitrogen in nitrite of potash (KO, NO_3)? From the relations of the two elements, to be noticed presently, this would seem probable, and in fact Frémy has noticed the crystallization of osmite of potash from a solution in hot water of the fused cake of nitre and iridosmium. A reason for osmic acid (OsO_4) being usually obtained from the latter, instead of osmious (OsO_2), might perhaps be found in the fact that the chemists who of late years have worked upon osmium recommend the use of nitric or nitro-muriatic acid to neutralize the potash—sulphuric acid, to which Wollaston had recourse in his early experiments, is now seldom employed. Thomson, in his "Chemistry of Inorganic Bodies," published many years ago, observes that osmic acid has sometimes a tint of yellow.

It does not seem likely that the cork closing the neck of the flask used for distillation had anything to do with the production of osmious acid, if such took place; the cork itself did not show any appearance of being acted on, and there was no blackening of its surface until some time after the experiment was ended.

The reduction of osmic acid generally results in the formation of the basic oxyds; Berzelius, however, observed that on adding sulphurous acid to a solution of osmic acid the latter passed through various shades of color—*yellow*, *orange-yellow*, brown, green, and at last blue; he attributed these tints to the successive formation of sulphates of the bin-oxyd, sesqui-oxyd, and blue oxyd; but may not the first step in the reduction have been osmious acid, giving the yellow color?

Another and altogether different view of the nature of the volatile yellow substance above described was suggested as possible by some remarks of Claus in a recent paper on the tendency to reduction of salts of iridium (Ann. d. Chem. u. Pharm., Aug., 1858, S. 129). This author has shown that the platinum metals fall naturally into these groups, in each of which are contained two metals resembling in general habit and relations each other more closely than members of the remaining groups. Platinum and palladium constitute the first of these pairs, iridium and rhodium the second, osmium and ruthenium the third. The atomic weight of the first-mentioned member of each pair is higher than (nearly double) that of the second.

In the paper quoted Claus remarks that the metal of lower atomic weight in each of these groups is much more easily reduced than the other from superior to inferior grades of combination with chlorine; thus the bichlorid of palladium is reduced with much greater ease to proto-chlorid than is the corresponding compound of platinum; and, for the same season, probably, the bi-chlorid of rhodium is not known, but only the sesqui-chlorid, while both salts of iridium can be easily obtained. On this same principle Claus explains the fact that no oxyd of ruthenium homologous with osmic acid has been obtained, while he gives the following reasons for suspecting the existence of such an oxyd: "This opinion is based upon the fact, that in my preparation of compounds of ruthenium, which can be obtained only by energetic processes of oxydation, the material worked upon, notwithstanding all my care and economy, gradually diminished, and yet I have never succeeded in collecting a volatile product. Once only, when I had fused ruthenium, perfectly free from osmium, with caustic potash and nitre, dissolved the mass in water, and decomposed it with nitric acid, I observed a peculiar odor, quite distinct from that of osmic or nitrous acid; and afterwards, having covered the beaker, which was smeared on the edge with tallow, with a plate of glass, I

remarked an unmistakable blacking of the tallow, caused by the reduction of a volatile metallic compound."

It seemed possible that the volatile yellow substance to which the present paper refers might have been an acid oxyd of ruthenium*—RuO_3, RuO_4, or RuO_5—and reducible with extreme facility, Claus and others having already noticed the reducing effect of light upon salts of the platinum metals. A portion of the crust from the sides of the tube of yellow acid was carefully examined for ruthenium, the various tests given by Claus as well as that recently proposed by Dr. Gibbs being made use of, but no proof of the presence of this metal could be obtained.

The properties of osmium and its compounds are very remarkable, and render it a matter of no little interest to trace the analogies of this rare substance and fix its place among the other elements. It is described in most chemical works along with platinum and its associated metals, mainly on the ground of community of origin, for in many respects it is unlike the platinum, palladium, rhodium, &c., with which it always occurs in nature. All these metals are commonly thought of as very infusible, of great density, very slightly affected by reagents, and very easily reduced from their compounds to the metallic state; when more closely examined they are found to differ from each other in many of their other properties. The arrangement by Claus of the platinum metals in these groups, each containing one metal of high and one of low atomic weight, viz.

Platinum,	Iridium,	Osmium,
Palladium,	Rhodium,	Ruthenium,

has been alluded to above; the two members of each group are more closely related to each other than to any of the rest. Osmium and ruthenium are clearly the most electro-negative of the series. Graham has inferred the isomorphism of platinum, palladium, iridium and osmium, from the fact that their potassio-chlorids all crystallize in the form of the regular octahedron; the corresponding compound of ruthenium has since been added to the list, while that of rhodium is still unknown. The occurrence of two salts under the same form, *in the regular system*, of

* If such a compound exist, an explanation may be found for the process by which Frémy has obtained a lower oxyd of ruthenium—probably the bin-oxyd—in crystals. He roasts the powder of platinum-residue in a stream of air drawn through a porcelain tube at a bright red heat; osmic acid volatilizes, and is said to carry with it *mechanically* the oxyd of ruthenium, which deposits upon fragments of porcelain placed in the cooler part of the tube. But the oxyd is in distinct crystals, and can therefore scarcely be conceived of as a powder borne along in a merely mechanical way by a stream of vapor; and, moreover, there is no reason for oxyd of ruthenium only being so borne along, while other substances of no greater density remain behind. Is it not more likely that a volatile and very easily reducible homologue of osmic acid is formed, and almost immediately afterwards decomposed, depositing the bin-oxyd of ruthenium?

course does not of itself suffice to establish the relation of isomorphism between them; iridio-chlorid of potassium seems however to be capable of crystallizing in all proportions with the platino- and osmio-chlorids.

The interesting fact has been discovered by Claus that osmio-cyanid and ruthenio-cyanid of potassium are strictly isomorphous with the well-known ferro-cyanid, crystallizing with it in all proportions, and even giving very similar precipitates with various metallic solutions; so that, in these double cyanids, osmium and ruthenium are capable of taking the place of *iron*.

In the greater number of its relations, however, osmium presents itself as a member of the *arsenic group* of elements. This has been noticed by some recent authors, as by Prof. Dana in the arrangement of the elements adopted in his System of Mineralogy, and by Prof. Miller, who says in his lately published Elements of Chemistry that "it presents more analogy with arsenic and antimony than with the noble metals." Frémy too compares osmium in platinum ore to arsenic in the native arseniurets.

Nitrogen, phosphorus, arsenic, antimony, and bismuth are generally recognized as forming a distinct and natural group of elements, and into this group it seems from many considerations that osmium, and probably ruthenium, ought to be introduced. They have some analogies with other natural families, just as arsenic is allied to sulphur in native sulph-arseniurets, and nitrogen and chlorine exhibit some resemblance in the nitrates and chlorates, but here appear to lie their closest relations. It may be interesting to notice some of the principal points of resemblance to or difference from this group.

Iridosmine occurs in crystals closely related in form to those of arsenic, antimony, and bismuth in the metallic state. The analyses of iridosmine are not yet sufficiently numerous or accurate to enable us to decide upon its normal composition, but it seems probable that the two metals occur in variable proportions, and are in this mineral isomorphous, thus establishing, as noticed by Dana, a connection between the arsenic group and that of the distinctly basic metals, as the arsenic and sulphur groups are united through homœomorphous bismuth, tetradymite, and tellurium. Dana places iridium in the same section with iron, among the metals whose most stable grades of oxydation are the prot-oxyd and sesqui-oxyd, but the statement of Claus that the *bin-oxyd* of iridium is the most stable and easily prepared compound with oxygen would remove this metal, as also perhaps platinum and palladium, from the iron section to that containing tin and titanium, and the propriety of this transfer may be supported by the relationship of Frémy's crystallized oxyd of ruthenium (doubtless the bin-oxyd) examined

by Sénarmont: This was found to be homœomorphous with stannic and (the rutile form of) titanic acid. The bi-chlorid of tin and potassium too is reported as crystallizing in regular octahedrons, like the corresponding salts of iridium, platinum, and palladium.

The arsenic section, as given by Dana, includes nitrogen, phosphorus, arsenic, antimony, bismuth, osmium, and tellurium. The last-named is marked as doubtful, and should decidedly be placed with sulphur and selenium, to which it is analogous in by far the greater number of its compounds.

In one of the interesting memoirs lately published by Dumas on the numerical relations subsisting among the atomic weights of the elements, the arsenic series is thus given:

	Atomic weights.
Nitrogen,	14
Phosphorus,	14+17=31
Arsenic,	14+17+44=75
Antimony,	14+17+88=119
Bismuth,	14+17+176=207

and the parallelism of this series with that of chlorine, iodine, &c., is supposed to be shown in the following lines:

F (19)	Cl (35·5)	Br (80)	I (127)
N (14)	P (31)	As (75)	Sb (122)

in which a common difference of 5 is assumed between the two members in each of the vertical columns (a difference not strictly brought out in the case of phosphorus and chlorine), and in which antimony is given a higher atomic weight than in the preceding table. Osmium is not included, but in a supplemental note since published we find it placed, with an equivalent somewhat higher than that usually adopted, in the *sulphur* group, serving to complete the following two lines of equivalents:

Mg (12·25)	Ca (20)	Sr (43·75)	Ba (68·5)	Pb (103·5)
O (8)	S (16)	Se (39·75)	Te (64·5)	Os (99·5)

between the paired members of which a common difference of 4 is supposed to exist.

Let osmium and ruthenium be brought into the arsenic group, and the series of atomic weights will then stand thus:

	Atomic weights.
Nitrogen,	14
Phosphorus,	14+17=31
Ruthenium,	14+17+22=53
Arsenic,	14+17+44=75
Osmium,	14+17+66=97
Antimony,	14+17+88=119
Bismuth,	14+17+176=207

The atomic weights of ruthenium and osmium are here assumed as 53 and 97, numbers not differing more widely from those commonly received—52·2 (Claus) and 99·6 (Berzelius)—than do several of those assumed by Dumas. Our knowledge of these two equivalents is based upon very limited data, and can but be looked on as approximative merely. As regards osmium, Frémy says that in several experiments he has obtained an equivalent number lower than that given by Berzelius, and the vapor-density of osmic acid, which we shall notice presently, points to an equivalent close to 97. A re-determination of this equivalent is very much to be desired.

Taking the series as given above, we find ruthenium and osmium to fall in between phorphorus and arsenic—arsenic and antimony; the numbers from phosphorus to antimony increasing by 22—44—66—88, just as in the following group given by Dumas:

	At. wts.
Chromium, - - -	26
Molybdenum, - - -	26+22=48
Vanadium, - - -	26+44=70
Tungsten, - - -	26+66=92

and we may arrange the two series in parallel lines,

P (31)	Ru (53)	As (75)	Os (97)
Cr (26)	Mo (48)	V (70)	W (92)

These numerical relations are of very little importance in themselves, when we employ the small numbers of the hydrogen scale of equivalents, and especially when we permit ourselves to alter the numbers themselves to any extent, however small, but they acquire more interest when they present us with groupings of elements which we acknowledge on other grounds to be naturally related. In such cases, when the homology is distinctly marked, we may even be justified in taking some liberties for the moment with the numbers standing, often with but slender evidence to support them, for the equivalents of the less-known elements; and we may, perhaps, thus be directed to errors of determination which future experiments will clear away.

The bodies named in each of the two lines just given are homologous in many respects besides that of atomic weight, and a connection between the two series, through vanadium, has lately been shown by Schafarik. There is a clear resemblance running through the formulæ and properties of their oxyds. In the chromium series—a very natural one—the most important oxyds are the metallic acids of the composition MO_3; we have also in each case a bin-oxyd, MO_2; but the sesqui-oxyd is prominent only in the case of chromium itself, and indicates the relation of this metal with iron.

In the arsenic series the known oxyds are the following:

	P_2O					
NO	PO	RuO	AsO(?)	OsO	SbO(?)	BiO(?)
		Ru_2O_3(?)		Os_2O_3(?)		
NO_2		RuO_2		OsO_2		
NO_3	PO_3	RuO_3	AsO_3	OsO_3	SbO_3	BiO_3
NO_4	PO_4(?)			OsO_4	SbO_4	BiO_4
NO_5	PO_5		AsO_5	OsO_5	SbO_5	BiO_5(?)

The prominent compounds in the table are the acids, MO_3 and MO_5; with respect to the separate columns the following facts are noticeable.

The oxyds of nitrogen are well known; the regularity observable in this column causes it to be frequently used as an illustration of the "law of multiples." NO and NO_2 are usually said to be neutral, but the latter plays the part of a base in contact with sulphuric acid, as in the crystals of the oil of vitriol chambers, and possibly the former may do so too in the nitrosulphates (KO, NO, SO_3 and NH_4O, NO, SO_3?) obtained by Davy by bringing nitric oxyd in contact with an alkaline sulphite. NO_3 and NO_5 are well-known acids. It is doubtful whether hypo-nitric acid (NO_4) is capable of combining with bases and forming salts; in contact with the alkalies it yields a mixture of nitrites and nitrates, yet, *when out of contact of bases, it seems to be a body of more stability than either* NO_3 *or* NO_5 (*anhydrous*).

In the column of the oxyds of phosphorus, we have first the very anomalous sub-oxyd (P_2O), which is probably the only marked exception to the homology running through the whole table. Before the discovery of red (amorphous) phosphorus by Schrötter this substance was, no doubt, to some extent confounded with phosphoric oxyd, and may even now throw some doubt upon the cases in which the latter seems to have been obtained pure and to have yielded a formula supported by trustworthy analyses. PO, unlike the other protoxyds of the series, is usually considered an acid, but as it has not been obtained in the separate state, and all the hypophosphites contain water, it may be reasonably assumed that the formula of the acid should include hydrogen. PO_4 is doubtful; this may, perhaps, be the composition of Pelletier's phosphorous acid, produced by the slow combustion of phosphorus, a body which undergoes no further oxydation by prolonged exposure to the air, and which, in contact with bases, yields mixed phosphites and phosphates. The last term in the column—phosphoric acid—is well known.

The existence of a distinct protoxyd of arsenic, as of antimony and bismuth, is doubtful. Arsenious acid is *a feeble, volatile, me-*

tallic acid—feebler in its relations as an acid than arsenic acid, and volatilizing at a lower temperature than the latter. Arsenious acid, moreover, volatilizes at a temperature below that required by metallic arsenic.

In the antimony column, the oxyd SbO_3 is usually viewed as a weak base, but seems also to be capable of uniting as a feeble acid to the alkalies, and even of expelling carbonic acid from their carbonates (Liebig). The iso-dimorphism of SbO_3 and AsO_3 is well established. SbO_3 is volatile at quite a moderate temperature, while metallic antimony requires at least a white heat to vaporize it. SbO_5 is a body of distinctly acid properties. *Both* SbO_3 *and* SbO_5 *are converted by heating in the air into* SbO_4 —the so-called antimonious acid—which seems therefore to be the most stable oxyd when strong bases and acids are not present. It is most probable that, as Frémy maintains, SbO_4 is not itself an acid, but that a so-called alkaline antimonite is in fact a mere mixture of an antimoniate with the compound of antimonic oxyd and alkali ($2SbO_4 = SbO_3 + SbO_5$).

In the bismuth column, the teroxyd is homologous as a base with teroxyd of antimony, but shows little tendency to play the part of an acid with even the strongest bases. This oxyd and the metal itself are volatile at high temperatures. BiO_4 also seems to be devoid of acid properties, but the compound BiO_5 probably exists, and is homologous with SbO_5, forming alkaline salts of little stability.

Comparing now ruthenium and osmium with the above recognized members of the arsenic group, we find first that both metals form protoxyds, which are feeble bases, as are probably the corresponding compounds of the other members of the group. We next meet with the sesquioxyds, whose formula is exceptional in the series, but for neither metal has this grade of oxydation been obtained in the free state and pure, and in the case of osmium its existence may be gravely doubted. Anhydrous Ru_2O_3 is supposed by Claus to be formed during the roasting of metallic ruthenium in the air at a high temperature, but only on the ground that the absorption of oxygen slackens when *about* enough has been taken up to form this compound, and that the proportion necessary for the binoxyd is never fully attained. Claus, however, describes a sesquichlorid with which double salts are formed by the chlorids of potassium and ammonium, and we must therefore assume a sesquioxyd also. Sesquioxyd of osmium is quite unknown in the separate state, and the belief in its existence is founded solely upon the preparation by Berzelius of a dark brown substance, supposed to consist of the sesquioxyd united to ammonia, which, dissolved in hydrochloric acid, yields a brown compound, supposed to be the sesquichlorid of osmium and ammonium. Neither of these, however,

can be crystallized, nor has the constitution assigned to either been supported by an analysis. The so-called ammonio-sesquioxyd detonates when heated, (sometimes with much violence, as I have noticed in removing by heat the deposit of this substance which forms on the end of a retort-neck during the distillation of osmic acid into a receiver containing ammonia,) and hence is probably analogous to fulminating platinum, containing perhaps the binoxyd of osmium. The binoxyd itself is a feeble base, the characteristic color of whose salts in solution is yellow as is the case with the corresponding compounds of iridium. Similar remarks apply to the binoxyd of ruthenium—probably the body obtained, as we have shown, by Frémy in crystals. The teroxyd of osmium is the body supposed to have been isolated in the experiment described at the beginning of this paper. Its position as a feeble acid, capable, however, under some circumstances, of playing the part of a base, its fusibility and volatility (greater, apparently, than those of osmic acid, as nitrous acid is more fusible and volatile than hypo-nitric), its probable crystallization in octahedrons of the regular system, in which arsenious acid and teroxyd of antimony are also found, all tend to indicate homology with the other teroxyds of the arsenic group. The general relations of ruthenic acid, so far as these are known, place it in a similar position. Just as we find hyponitric acid (NO_4) and antimonious acid (SbO_4) to be the most stable of the higher oxyds of nitrogen and antimony, so the well known osmic acid (OsO_4) seems to be the grade of oxydation which osmium most readily assumes and retains when not in contact with bases. OsO_3 and OsO_5 (the latter as described by Frémy) seem scarcely capable of existing in the separate state; when set free from their salts they soon pass into OsO_4; while it may as well be doubted that the latter ever exists as a distinct acid in combination with bases as that NO_4 or SbO does so. No so-called osmiate has ever been analyzed; the saturating capacity of the acid, if it be such, is unknown; when free and in solution in water it has no acid reaction, it does not displace carbonic acid from the carbonates, and it is itself expelled by heat from most of its supposed compounds, and is separated in part by water even from potash and soda. No compound of OsO_4 with a base has been obtained in crystals, while Frémy states that he has crystallized the alkaline salts of both OsO_3 and OsO_5. RuO_4 and RuO_5 are as yet unknown.

The tendency throughout the whole arsenic group is manifestly to the production of the acid compounds MO_3 and MO_5, the former the more fusible and volatile body, the latter the stronger acid. In addition we have some cases of the protoxyd (MO), a feeble base, and the binoxyd (MO_2), a body of still more feebly basic properties, verging upon the acids. All other grades of

oxydation, so far as they exist at all, may perhaps be correctly viewed as compounds of the preceding *inter se*. The stability of the oxyd (MO_4) in the separate state is remarkable—its formula is one of rare occurrence.

The affinity of all the elements of the group for oxygen is considerable; it is so even in the case of osmium and ruthenium, usually placed among the noble metals. Dumas (*Traité de Chim. app.*) states that osmium does not oxydize at common temperatures, nor even at 100° C., but I have obtained conclusive evidence that oxydation may go on slowly even at the ordinary atmospheric temperature. The paper label and the cork of a tube containing pure metallic osmium have in the course of several years become blackened, precisely as organic matter is by the fumes of osmic acid, the black tint on the paper decreasing from the mouth of the tube along the outside. A piece of white paper in which some black platinum residue had been wrapped, was strongly stained in the immediate neighborhood of the powder in the course of a few weeks. *The same effect is distinctly observable even upon the paper label placed inside a tube of native iridosmine* (Siberian) *in the usual coarse grains*—a specimen which has lain among other minerals, and has never been placed near any artificial preparations of osmium. Osmium, like arsenic and antimony, is clearly capable of slowly taking up oxygen at common temperatures. At a red heat, roasting in a current of air affords, as is known, a good method of obtaining osmic acid from the iridosmine of platinum residues—just as by similar roasting arsenious acid is prepared from the native arseniurets.

It would be a matter of much interest to compare osmium with its supposed homologues under circumstances in which we should expect it to play an electro-negative part. Frémy has announced his belief in the existence of an *osmiuretted hydrogen*, but such a body has not yet been isolated and described. Compounds of the metal with ethyl, methyl, &c., would be well worth examination, and it is not unlikely that such might be prepared from a body which in some states of combination exhibits such a high degree of volatility.

The earlier experiments of Deville and Debray upon the platinum metals seemed to have shown that both osmium and ruthenium could be volatilized, at exceedingly high temperatures, without previous fusion; if this were confirmed, a strong point of resemblance with arsenic would be made out, but it appears from a more recent paper that osmium at least may be fused and obtained as a perfectly compact mass, the apparent volatility of the metal being due doubtless to previous oxydation, the crucibles used being permeable to air. We have seen, as regards arsenic and antimony, that their oxyds are more volatile than the metals themselves.

It is lately stated that osmium may be obtained in crystals by the same means as those used for boron and silicon, but I have as yet seen no account of the form which it assumes.

Deville has furnished another interesting fact with respect to osmium, by determining the density of the vapor of osmic acid, which he has found = 8·88. This, if we take the generally received atomic weight for osmium, gives the atomic volume $\frac{131·6}{8·88}$=14·82, indicating a condensation to 2 vols. If we now calculate back to the theoretical atomic weight we get (14·57× 8·88)−32=97·38, a number closely approaching 97, which, as we have seen, brings the equivalent of osmium into simple and harmonious relation with those of the other elements of the arsenic group.

The specific gravity of fused metallic osmium having been lately determined by Deville =21·4, there can be little doubt that all the metals of the platinum family possess the same atomic volume when in the free state, about 4·6 or 4·7; the specific gravity of ruthenium is not yet known with accuracy, but such experiments as have been made render it improbable that it will prove an exception. This number is about one-fourth the mean of the at. vols. of the long recognized members of the arsenic group, but these latter differ so widely among themselves* that the comparison is of little or no value. It would be desirable to get a good determination of the density of osmic acid in the solid state, so that its at. vol. might be calculated and compared with that of antimonious acid.

The specific heat of osmium, so far as its value as a physical character goes, *opposes* the introduction of this element into the arsenic group. It has been determined by Regnault =·03063; multiplying now by the equivalent 97, we have the product, 2·9711, thus placing osmium in the list of the elements (including the majority) for which the product of sp. ht. by at. wt. is nearly 3, while for phosphorus, arsenic, antimony and bismuth the product thus obtained is twice as great, or about ·6. In this respect, however, osmium probably resembles nitrogen—the latter examined, as it necessarily is, in the gaseous form.

It is to be hoped that the conducting power for heat and electricity of compact osmium will soon be examined; nothing is as yet known of these characters.

* Phosphorus, - - - - $\frac{31}{1·83}$ (*Schrötter*) =16·94

Arsenic, - - - - $\frac{75}{5·67}$ (*Herapath*) =13·23

Antimony, - - - - $\frac{119}{6·7}$ (*Karsten*) =17·76

Bismuth, - - - - $\frac{207}{9·8}$ (*Marchand & Scheerer*) =21·12

Lastly, as regards the magnetic relations of the element—it is placed, with some doubt, by Faraday in the paramagnetic class; the metal and its protoxyd were found to act feebly in this sense, while pure osmic acid is said to have shown itself clearly *diamagnetic*. The strongly diamagnetic character of phosphorus, antimony and bismuth would render a re-examination of this point interesting. Arsenic, however, is said to be very feebly diamagnetic, and is placed by Faraday close to osmium in the list of metals examined, though on the opposite side of the line of magnetic neutrality or indifference.

Reviewing, now, the united physical and chemical characters of osmium, and comparing them with those of the generally recognized members of the "arsenic group," we are, I think, justified in concluding that here this curious metal should be placed in a natural arrangement of the elements—while important distinctions seem to separate it from some, at least, of the platinum metals, with which it is usually associated and described.

Tuscaloosa, Ala., Nov. 1, 1859.

ART. VII.—*The Comas and Tails of Comets;* by Prof. W. H. C. BARTLETT, U. S. Military Academy at West Point.

COMETS have, at all times, been objects of curiosity and wonder; and the question in regard to the nature of their luminous appendages, has exercised the speculative ingenuity of philosophers from the earliest records of astronomy. Everything written about them is read with interest, and the most extravagant theories in respect to their constitution and the laws of their being find a ready favor with the public. They are still among the enigmas of the heavens. Among the recent and remarkable efforts at solution, is one by the ablest mathematician of the country, perhaps of the age: and granting the premises, there is no avoiding the conclusions of the comprehensive and searching analysis for which this eminent man is so remarkable. But the assumption, that the attractive energy which summons a comet from the depths of space to the presence of the sun, retains its nature unchanged and strengthens with the diminution of distance for a part of the approaching mass, and yet reverses its character and becomes repulsive for another part, in order to obtain material to build up the tail, appears so unsupported by the analogies of nature as to give to his results the taint of improbability. Indeed, a theory which demands such an exercise of faith in matters of science, and from such friends, can only inspire doubt, and should yield the place it has too long occupied

to some other, founded in better ascertained laws of matter. The question is not one of pure mathematics, but of physics.

The material elements of all bodies of which we have any knowledge, are united by some conditions of aggregation, determined by the reciprocal action of molecular forces; and the circumstances of their relative motion will come from the equation

$$\Sigma m.\left[\left(\frac{d^2x}{dt^2}-\mathrm{X}\right)\delta x+\left(\frac{d^2y}{dt^2}-\mathrm{Y}\right)\delta y+\left(\frac{d^2z}{dt^2}-\mathrm{Z}\right)\delta z\right]=0;$$

in which m is the mass of an element, xyz its coördinates of place, X Y Z the sums of the components of impressed accelerations in the direction of the axes $x\,y\,z$, respectively.

The conditions of aggregation may be expressed in some functions of the coördinates of molecular places. As three coördinates determine the place of a single molecule, there will be three times as many coördinates as molecules; and if μ be the number of molecules and λ the number of equations that give the conditions of aggregation, then will $3\mu-\lambda=n$ be the number of coördinates which, if given, would reduce the number of unknown coördinates to the number of equations. These unknown coördinates could then be found, and the places of the molecules at the corresponding instant determined.

Denote the λ coördinates by $x\,y\,z$, $x'\,y'\,z'$, &c., and the n coördinates by $\alpha\,\beta\,\gamma$, $\alpha'\,\beta'\,\gamma'$, &c. The former of these coördinates, as also the forces, may be expressed in functions of the latter, and both eliminated from the general equation of motion. And if $\xi\,\eta\,\zeta$, $\xi'\,\eta'\,\zeta'$, &c., be the increments of $\alpha\,\beta\,\gamma$, $\alpha'\,\beta'\,\gamma'$, &c., at any instant and due to any transmitted initial disturbance, it is easily shown that

$$\begin{aligned}
\xi &= \Sigma\,\mathrm{R}.\mathrm{N}_{\xi}.\sin\left(t.\sqrt{\varrho}-r\right),\\
\eta &= \Sigma\,\mathrm{R}.\mathrm{N}_{\eta}.\sin\left(t.\sqrt{\varrho}-r\right),\\
\zeta &= \Sigma\,\mathrm{R}.\mathrm{N}_{\zeta}.\sin\left(t.\sqrt{\varrho}-r\right),\\
\xi' &= \&c. \qquad \&c. \qquad \&c.
\end{aligned}$$

In which there are n terms comprehended by the sign Σ, and in which ϱ will, in general, have different values from one term to another. When these values of ϱ are real and positive, the different terms in the values of $\xi\,\eta\,\zeta$, &c., will disappear periodically, the precise times of disappearance being given by

$$t.\sqrt{\varrho}-r=a\pi;\quad t'\sqrt{\varrho'}-r'=a'\pi;\quad \&c.,\ \&c.$$

or

$$t=\frac{a\pi+r}{\sqrt{\varrho}};\qquad t'=\frac{a\pi+r'}{\sqrt{\varrho'}};\quad \&c.,\ \&c.$$

in which a is any whole number. The intervals of disappearance will be

$$\frac{\pi+r}{\sqrt{\varrho}};\quad \frac{\pi+r'}{\sqrt{\varrho'}};\quad \&c.\quad \&c.;$$

and if these intervals be commensurable, all the terms will dis-

appear simultaneously, and $\xi\,\eta\,\zeta$, &c., reduce to zero, at equal intervals of which the duration is

$$t_i = \frac{\pi + r}{\sqrt{\varrho}} \times \frac{\pi + r'}{\sqrt{\varrho'}} \times \&c. \times \&c.$$

The vast atmosphere of ether which pervades all space is ever busy transmitting luminiferous waves from the sun and other heavenly bodies. Its molecules are ever on the move with velocities and in orbits determined by the relative places and intensities of existing wave sources. Any cause which will perturbate the etherial molecules of any limited volume of ether from these orbits, regarded as initial, and by the quantities $\xi\,\eta\,\zeta$, $\xi'\,\eta'\,\zeta'$, &c., will make such volume *self-luminous;* and if the perturbation be great enough, it will be visible from all directions.

Comets are known to exist in a state of great tenuity, their densities being almost insignificant in comparison with that of the fleecy clouds that float in the upper atmosphere. The luminiferous waves from the sun, entering such bodies with great ease, their intromitted greatly preponderate over their reflected components. The former of these components modify and determine the internal motions of comets, and make them *self-luminous.* The internal cometary elements become so many centres of disturbance. They throw their waves in all directions, and are simultaneously sources of molecular perturbations to the surrounding ether, each giving rise to a term $\mathrm{R.N.}Sm\,(t.\sqrt{\varrho} - \gamma)$, in the general value of the perturbating functions $\xi\,\eta\,\zeta$, &c., and thus making the ether also *self-luminous.* The degree of illumination will vary with the maximum values of the perturbating functions. These will result, in any case, from the extent of the initial disturbance and the distance, at right angles thereto, over which the disturbance may have been propagated; decreasing, according to the principle of wave divergence, as the square of this distance increases. The components of the initial disturbance perpendicular to the line drawn from the comet to the sun, is, from the principle of wave propagation, much greater than in any other direction; and hence the much greater extent of the illumination on the side of the comet opposite the sun. The comet's head can have no phases, from its self-luminosity; neither can the coma and tail have sharply defined outlines, from the gradual degradation of molecular perturbations towards their borders.

This view denies the presence of cometary material in the coma and tail altogether, and regards these appendages but as phenomena due to the reciprocal action of the etherial and cometary molecular forces. According to it, the coma and tail become, as it were, *a luminous shadow,* a part of which is literally "cast before," and the dark cap which envelopes the head and

stretches away through the tail, a region of *wave interference*. No wonder, then, that comets turn their tails from the sun, and, at perihelion, whisk them, though of enormous lengths, through celestial arcs well nigh equal to a semi-circumference, in a few hours. This is no more surprising than that opaque bodies throw their shadows from the luminous sources whose light they intercept. The curvature, which is so remarkable a feature in the tail, is but the simple effect of the comet's orbital velocity, and the progressive motion of light.

If the principles here cited be well founded, then will the zodiacal light find an easy solution; and the great oblateness of its spheroidal figure must be taken as evidence that the component molecular motions in the sun are greater in the direction of the solar axis than in any other.

West Point, Oct. 25th, 1859.

ART. VIII.—*On Sodalite and Elæolite from Salem, Massachusetts;* by J. P. KIMBALL, Ph.D.

FOR a knowledge of this locality of the occurrence of the two rare silicates, sodalite and elæolite, we are greatly indebted to Gilbert L. Streeter, Esq., of Salem, as well as to several other gentlemen of the same city. Fortunately, Mr. Streeter very carefully observed their mode of occurrence, and, together with G. F. Cheever, Esq., and Rev. S. Johnson, Jr., collected choice specimens of them. The best of these are in the possession of the Essex Institute, Salem, to the curator of which, Dr. Henry Wheatland, I owe in a great measure the privilege of examining them.

The locality in which the minerals were found is "a pit or quarry, a short distance below the Almshouse upon the road passing along the northern side of the Neck, towards Hospital Point."* They were first noticed in a "block of compact syenite resting upon the bank, the end of which presented a beautiful coloring of blue and greenish white, with specks of black. Upon examination these conspicuous minerals were seen to be in a vein, a portion of which was connected with the block of syenite."†

Mr. Streeter subsequently discovered what undoubtedly was the continuation of the same vein. This traversed an erratic block of the same rock, imbedded in the drift, of which the small block, just mentioned, was a fragment. The vein is described to have been about six feet in width, and to have dimin-

* G. L. Streeter: Essex Institute Proceedings, ii, 153. † Ib.

ished in thickness "wedge-like to a mere line at the termination." Although this vein-stone was identical in its character with that of the smaller block, its yield of fine specimens of sodalite and elæolite was less abundant than that of the latter. Unfortunately enough, the discovery of the minerals was not made in time to rescue this precious vein-stone from the hands of the quarrymen. Large masses of it including, it is believed, the best specimens, had been carted away and buried deep beneath a littoral road along Collins' Cove. The quarry was opened in the autumn of 1855. I visited it last spring when it was not being worked, and found amongst the debris of the quarry very good specimens of both minerals. At that time a portion of the boulder which contained the vein was still left. This I identified as a syenitic porphyry (Quarzfreier Porphyr of Senft). It is characterized by remarkably entire crystals of oligoclase of a greenish color, which make up the base of the rock. Thickly disseminated through the base are minute grains of hornblende and scales of mica.

Besides the sodalite and elæolite, the vein-stone is composed of orthoclase for the greater part; biotite in black tabular prisms; small crystals of zircon in octahedral prisms; fine stellate brownish-yellow flakes of xanthosiderite; and (probably) albite in small, irregular, reddish, granular masses.

At Litchfield, Me.—the only other known locality in America where sodalite and elæolite occur together—these minerals are further associated with cancrinite and, as at Salem, with zircon; but instead of occupying a vein as in the Salem instance, exist as accidental constituents of a granitic rock composed of quartz, feldspar and black mica,* thus constituting a miascite analogous to that of the Ilmen mountains.† The Litchfield rock, to be sure, is found only as erratic blocks; but the absence of cancrinite in the Salem boulder, and the dissimilarity between this and the Litchfield rock as to petrographic character, tend to preclude the possibility of the two having a common source.

Sodalite.—The sodalite from Salem has quite the same character as that from Litchfield and the Ilmen Mts., with specimens of which I have been able to compare it, excepting that the former in common with the elæolite, is contaminated with minute particles of what appears to be mica, thus rendering it very difficult to glean perfectly pure mineral for analysis. It is in crystalline, sub-translucent masses having an indistinct cleavage. Its lustre is greasy, and its color beautiful lavender blue.

Three separate determinations of its specific gravity were made with different portions of the mineral, giving the results as follows: 2·294, 2·303, 2·314.

* J. D. Whitney: Poggendorff's Annalen, lxx. 434.
† Senft: Classification und Beschreibung der Felsarten, 218.

Two portions of the mineral were used for the analysis. The one portion was treated with nitric acid, and the chlorine determined as chlorid of silver. The other portion was treated with diluted hydrochloric acid, whereby the silica, alumina, lime and soda were determined according to the customary methods.

Prof. J. D. Whitney,* in his analyses of the sodalite and its associated minerals from Litchfield, has so fully observed their chemical properties as to render superfluous here any remarks on the same subject.

Calculating all the sodium as soda, the following results are obtained:

Silica,	37·33
Alumina,	32·70
Oxyd of iron,	*trace.*
Soda,	24·31
Chlorine,	6·99
	101·33

But on the other hand, assigning to the percentage of chlorine enough of sodium to form chlorid of sodium in accordance with von Kobell's formula of this mineral ($\dot{N}a^3\ddot{S}i+3\ddot{A}l\ddot{S}i+NaCl$), we have 18·17 for the percentage of soda in combination with silica.

Hence the analysis will stand thus:

Silica,	37·33	
Alumina,	32·70	
Soda,	18·17	
Sodium,	4·57	NaCl
Chlorine,	6·99	NaCl
	99·76	

These results are sufficiently in agreement with the established formula.

Elæolite.—The elæolite from Salem possesses all the constant physical properties of this variety of nepheline. Its color is dull green, its lustre greasy, and its fracture sub-conchoidal. It is sub-translucent, and in structure massive. Its specific gravity is 2·629. Its chemical composition I find to be as follows:

	I.	II.
Silica,	44·31	44·07
Alumina,	32·80	
Peroxyd of iron,	*trace*	
Lime,	·40	
Soda,	16·43	
Potash,	5·50	
Ignition,	1·47	
	100·91	

Schenectady, N. Y., September, 1859.

* Poggendorff's Annalen, lxx, 433.

ART. IX.—*Description of Nine new species of Crinoidea from the Subcarboniferous Rocks of Indiana and Kentucky;* by SIDNEY S. LYON and S. A. CASSEDAY.

PTEROTOCRINUS. *Lyon and Casseday.*

Asterocrinus, Lyon, Geol. Rep. Ky., vol. iii, p. 472.

SINCE our description of Asterocrinus was published in the 3d vol. of the Kentucky Report, we find the name to have been appropriated previously. We therefore propose Pterotocrinus as the name of our genus, which has now four well authenticated species.

Generic formula.

Basal pieces, 2	Mouth central, 1
Radial pieces, 1st series, 5	Column round, (?)
" " 2nd series, 10	Arms ciliated and single, 20
" " 3rd series, 20	Wings or lobed pieces, 5 } variously formed.
Anal piece, 1 or more.	

Pterotocrinus depressus, n. s.

Body, depressed, subconical, twice as wide as high; below the free arms it presents the form of a very shallow, flattened cup, the pieces composing it smooth and of equal thickness, in some cases nearly a plane, the margin curving suddenly upward at the junction of the arms; the vault rises from the arms at a very low angle, rapidly increasing towards the centre, where it is nearly perpendicular. *Column*—very small, formed near the body of circular pieces of unequal size and thickness. *Basal* pieces, two, similar in size and shape; not prominent. When joined, they together form an irregular pentagon, raised a little above the general surface of the cup; slightly indented at their junction with the column, which has one or more pieces buried in the pit in which it is attached.

Radial pieces of the first series, five; subquadrangular, similar in form and size, nearly twice as long as high. Radial pieces of the second series, ten, subquadrangular, differing slightly both in form and size, resting near the centre of the outer margin or the first radials, a little more than half covering them. The radials of the third series are twenty in number, differing slightly in size, subquadrangular, nearly twice as wide as high, ten of them resting upon the radials of the second series, the other ten resting partly on these and partly on the first radials. The radials of the third series support from four to five brachials of quadrangular form, four times as wide as high; from the summits of this last series the arms, which before had been horizontal, become quite erect, and are composed of a double row of pieces which join by angular sides in the center of the arms.

Anal piece, one; obtusely angular below, fitting into a depression of the basal pieces, rounding to a point above, rising above the first radials.

The vault is divided into five triangular spaces by the wings, five in number; each space is covered with seven pieces of a compressed hexagonal form, three rising from the arms from the first row; upon these rest two; in the angular space at the summit of these rests the sixth, similar in size to those below it; it is squarely truncated above, thus becoming pentangular; its upper margin supports a small quadrangular piece; there are some quite small pieces above this last, in our specimen, probably one row which may form the mouth; between each of the five fields of the vault is a long lanceolate piece as wide as the other pieces of the vault, and about three times as long as those in the fields; the wings are attached to these long pieces by an articulating joint, and extend beyond the arms which embrace the vault, diminishing in thickness from their attachment outward, and terminating in a thin knife-like edge, equal in width to twice the height of the vault, the upper and lower margins nearly parallel; obtusely rounded at their outer extremity.

The arms are single, twenty in number, lying in sets of four between the wings, which, being placed immediately above the centre of the first radials, divide them into pairs, two from each of the adjacent radials falling into the spaces between each pair of wings. The arms are provided with a row of cilia for each side, formed of short joints, placed immediately in contact one above the other, filling the length of the arms which rise above the wings, about one sixth of their length. The dermal coating has been lost from all the specimens we have seen. The sides of the wings are strongly marked by a muscular attachment, by which they were moved. (?)

By reference to the figures it will be evident that this differs from all heretofore described species; by the bipartite basal pieces it is related to *Dichocrinus*.

Dimensions of Specimen of Medium Size.

Height of base,	·20 inches.
" " vault,	·30 "
Diameter of arms,	·75 "
Length of "	·70 "
Greatest width across the wings,	1·69 "
Height from base to top of wings,	·85 "

Geological Position and Locality.—Several specimens have been found in the third intercalated limestone, of the Millstone grit, Grayson Springs, Grayson County. Same horizon, near Dr. Baker's furnace, Edmonson County, Ky.

Pterotocrinus pyramidalis, sp. nobis.

Body without the arms and winged appendages:—the vault is a pyramidal pentagon, nearly twice as high as the greatest diameter at its junction with the calyx. The calyx is vasiform, the rim of the vase slightly reflected downwards: four times as wide as high. Columnar pit deep, irregularly oval, the longest diameter transversely disposed with reference to the anal side. Columnar facet round, perforation not visible (in any specimen that has come under our observation).

Basal pieces, two; prominent, outer margins thick and rounded, joined by a straight line to each other, the posterior margin having a deep angular notch, while the anterior side is but slightly indented at the

junction of the pieces; both pieces are irregularly pentagonal, nearly of the same form; that on the right of the anal piece being a little the largest.

First radial pieces, five; broad, sides diverging from below upwards, three times as wide as high, the ends of the upper margins parallel to the lower; about one-half of the length of the upper margin circularly depressed for the reception of two of the second radials to each.

Second radial pieces, ten; small, obscurely quadrangular, resting in the circular depression at the summit of the first radials, each pair being separated one from the other by a very minute anomalous piece, which rests on the center of the first radials between them; it is nearly round, and rises under the suture which marks the separation of the second radials, and is about one fourth the height of those pieces.

Third radials, twenty; small, differing both in size and form; nearly as high as wide, divided into five groups, disposed on a curved line, the exterior pair of each group resting partly on the first radial and partly against the oblique outer margins of the second radials. The central pair of all the groups rest upon the second radials, against those on either side and against each other. The articulating surfaces to which the arms were attached are slightly concave; the upper side deeply indented by a perforation into the body, partly in the arms and partly in the pieces immediately above them.

Anal piece, one; large, as compared with other species of this genus, long, hexagonal, obtusely pointed below, resting in the deep angular notch in the basal pieces; diminishing gradularly upward, supported on either side by the first radials; acutely pointed above, reflected toward the body, and supporting on either side one of the third radials.

Our specimens are weathered to such an extent that all surface markings (if they ever existed) have been removed.

Summit.—The summit above the arms is divided into five fields, nearly of the same form and size, that above the anal side being a little the largest; they are covered by hexagonal or pentagonal pieces higher than wide. The largest field has four pieces in the first row, the other fields having only three each; the outside of each of the first series is articulated with a piece at the base of the wings, the second range and the superior margins of the third radials. Dividing the first range of pieces are five projecting angular pieces inserted between the groups of the first range, touching the third radials at one of its angular points, rising from them by a line slightly curved outward; they articulate with the first and second range of the five fields and with the wings, in the same manner as *P. depressus* (nobis). The second range consists of three long pentangular pieces, in the field above the anal piece, and two to each of the others. The third range consists of one lanceolate piece to each of the regular and two (?) to the irregular side. Between the fields of the summit is a broad articulating surface, about as wide as the pieces covering the fields, formed by the reflected margins of those pieces, and the supporting piece at the base of the wings. *Wings*—none have been found attached; great numbers are found loose, which we refer to this species. They are of various forms. The articulating surface applied to our specimen precisely fills and fits the articulating surface upon it; they are thick near the junction with the body, curved both above and below, gradually running to a point, five times as long as thick, broad on the upper surface,

gradually thinning downward; the outer end round and pointed; they are frequently found bifurcate near the end and double pointed: affixed to the specimen they radiate regularly and horizontally, the points being about as high as the summit of the specimen.

Mouth, central.

Arms, twenty; form unknown.

Column, unknown.

Dimensions.

Greatest diameter of calyx, - - -	·80 inch.
" " " basal pieces, - -	·49 "
" " " columnar facet, - -	·05 "
Height of calyx, - - - -	·18 "
Height of specimen, small part lost, -	·75 "
Length of wing articulations, with body, -	·45 "
Width " " " " -	·12 "
Height of first radial pieces, - - -	·12 "
Width " " " - - -	·35 "

Geological Position and Localities.—Found only in beds near the top of the third limestone of the Millstone grit series of Edmondson, Grayson and Breckinridge counties, Kentucky.

Fragments very abundant, good specimens rare. Beds from one to two feet thick are found composed of a mass of the remains of this crinoid cemented together, forming a distinctive and characteristic bed of the 3rd limestone.

Pterotocrinus rugosus, nobis.

The condition of our specimen is such that a particular description cannot be made: the arrangement of the parts, however, is evidently quite similar to that of *P. depressus*. The basals, first, second and third radials, are present, together with parts of the wings and a portion of one of the arms. This species differs remarkably from *P. depressus*, in the greater thickness of the pieces, prominence of the base, the knobby protuberances upon it and upon the first radials, the depth of the columnar pit, as well as by its roughness and more robust appearance.

Geological Position and Locality.—A single crushed and imperfect specimen was found in the lowest siliceous mud bed,* at the Falls of Rough Creek, Breckinridge county, Ky. Fragments of this species are quite abundant.

The beds at Rough Creek, Grayson Springs, Grayson county, and Baker's Furnace, Edmondson county, are doubtless the equivalents of each other. In the western edge of Breckinridge county, they are separated by a thick sandstone, where the upper division of the limestone appears to be the equivalent of the beds above enumerated. The size and proportions of this species is about the same as *P. depressus*.

Zeacrinus ovalis, sp. nobis.

Body—When the arms are closed the body is ovoid, the length being equal to about twice the diameter; concave at the base.

Basal pieces, five; minute, forming a pentagon, slightly indented at the sutures marking the division of the pieces. When the column is present, the basals and about half of the subradials are concealed. *Sub-*

* Equivalent to limestone No. 3, Millstone grit.

radial pieces, five; four of which are of the same form and size; lanceolate, obtusely pointed at the superior extremity; the fifth is large, irregularly pentagonal; one of its sides supports two of the anal pieces. *First radials*, five; differing considerably in size; the anterior one being symmetrical and the largest, the other four are unsymmetrical, the inferior side toward the anal field being longer than the inferior anterior side; they diminish regularly from the anterior to the posterior side. The *second radials* in all but the anterior ray are pentagonal, twice as wide as long, on the upper beveled sides of each supporting two arms. The second radial of the anterior ray is twice as wide as high, supporting on its upper side a third radial similar in size and form to the second radial of the other four rays, and like them it also supports a pair of arms. The *arms* are ten in number. The antero- and postero-lateral rays are composed of three quadrangular and one pentagonal piece each; one of the antero-lateral rays has the same form and number of pieces as the other and the anterior rays are composed of two quadrangular and one pentagonal piece each, somewhat larger than the pieces of the other rays. The inner upper margin of the last piece in all the rays support each one division of the ray, which is composed of about forty-five quadrangular pieces each, gradually diminishing in size to the end of this division of the ray, which is thus terminated in a point. The outer margins each support a branch which is bifurcated on the fourth, fifth or seventh piece, similar in form and arrangement to the first branch of the rays, the pieces being nearly as high and about half as wide as those below. The inner beveled upper margin of each last piece supports a branch which is of the same form as the inner branch below, composed of quadrangular pieces, terminating at the same height as the other branches. The outer margin of the second bifurcation of the anterior ray has in like manner an undivided branch of the same form and length; all the other rays are again bifurcated on the fifth or sixth piece, each division bearing two branches similar in form to the upper part of the inner divisions below; the anterior ray in its last division consisting of six fingers, all the others having eight fingers each, 46 fingers in all. The *fingers* are ciliated their entire length with a row on their inner margins.

Anal pieces, eight; the two inferior pieces rest partly on the subradials and partly against the first radials on either side, one rising nearly as high as the upper margin of the first radial against which it rests; upon these two rest two of the second range, and on the left side one quite minute, making the upper margin of the field nearly horizontal; the last two support one subquadrangular piece (the largest in the anal field) above which are three of the same form rapidly diminishing in size, thus running the anal field to a point.

Columns delicate pentagonal (near the body), composed of alternately larger and smaller thin pieces.

Dimensions.

Total length, - - - -	1·25 inches.
Greatest diameter, - - -	·62 "
Height of calyx, - - - -	·05 "
Greatest diameter of calyx, - -	·50 "

Length of finger, first bifurcation, -	-	·94	inch.
" " second " -	-	·80	"
" " third " -	-	·45	"
Depth of columnar pit, - -	-	·05	"

Geographical Position and Locality.—Found in the third limestone of the Millstone grit beds of Grayson, Breckinridge, Edmondson and Todd counties, Kentucky.

It has not been found in any other geological horizon in the Millstone grit beds of Western Kentucky, and may be classed amongst the distinguishing fossils of this particular bed of limestone.

Remarks.—Our species, in the arrangement of the calyx, approaches *Z. Worthenii* (Hall), from which it differs in having three instead of four primary radials; also in the number of pieces in the first branches of the rays. It differs from *Z. magnoliæformis* (Troost) in the arrangement of the calyx, the first radials and subradials being much shorter in our species.

Cyathocrinus dekadactylus, nobis.

Calyx, vasiform, spreading rapidly from the base, comprising all the pieces up to the second radials. The pieces forming it are thick, tumid, with long strong arms. Vault unknown. Column obtusely pentangular, covering nearly one half of basals; articulating surfaces crenulated on their borders.

Basal pieces, five; pentangular, forming together a marked stellate figure; upper facets prolonged into nearly acute angles; under surface slightly excavated.

Sub radials, five; hexagonal or heptagonal, somewhat irregular in size; they alternate with the basals; very tumid and thick.

Radials, five; the first are large, various in their shapes, generally septangular, sometimes broader than high, in other instances as high as broad; they support each two other radials, the first of which are thin, parallelogramic pieces much rounded on their outer surfaces; the last radial pieces are pentagonal, rather acuminate, more than twice as wide as high, and support on their bevelled edges two arms each, making $5 \times 2 = 10$ arms in all.

Arms.—The arms are apparently without any subdivisions throughout their whole length. They come off immediately from the radials; the first two armpieces are anchylosed, the arms becoming free and separate on the second armpieces. They are composed of thick pieces, rounded on their backs, about equal in size, and regularly superimposed upon each other. They are about one half as large as the last radials, and have a shallow sulculus (ambulacral groove,) (?) on their inner surface.

Anal piece, one; trapezoidal in shape, the upper margin reflected, pentangular, the middle portion of the piece intumescent. In two well preserved specimens we cannot trace any pieces superposed upon the anal piece.

At the juncture of any three pieces composing the calyx, there is a depression, which attains its greatest depth along the suture lines of the pieces. These depressions are an easily distinguishable character of this

species. The surface markings and proboscis (if one existed) are not preserved in any examples before us.

The spaces between the radials supporting the arms are quite extended and present the form of a Doric arch.

Geological Position and Locality.—Sub-Carboniferous beds of Montgomery county, Indiana. Rather rare.

Cyathocrinus hexadactylus, sp. nob.

Body, compressed, crateriform, robust, with long arms; surface covered with minute granulæ, arranged apparently in rows parallel to the margins of the pieces. The column is comparatively small, composed of alternating thick and thin pieces; the articulating surfaces are crenated, the larger and thicker pieces project over the thinner ones, the projecting edges being distinctly rounded.

Basis—Composed of five sublanceolate pieces forming together an irregular pentagonal figure. The columnar pit is small, occupying about one-third of the basis, slightly depressed, with a large central opening.

Subradials—Three of them are nearly equal in size, hexagonal, generally higher than wide; the remaining two are larger than the others, not constant in their shape, being quadrangular, pentangular and hexangular in different individuals. They alternate with the basals, are very convex, from their centres project two obscure folds which proceed to the radial pieces, where they join similar folds, thus enclosing a triangular depression, which is considerably deepened at their junction with any two radial pieces. These plicatures are faintly marked, and can be seen only on specimens when in a good state of conservation.

Radials—The first are large, wider than high, fitting into the retreating angles of the subradial pieces, equal in size; near the middle of the upper surfaces of each, and at the juncture of the two adjoining folds from any two adjoining subradial pieces, come off the remaining radials, which are two in number, small, the last axillary. The second radials fit into a facet which is scooped out of the upper part of the face of the first radials, and are bordered by a small emarginate plicature, slightly raised and reflected outwards.

Anal pieces, two; the first is obscurely pentangular, the fifth facet being hardly perceptible; it is hemmed in entirely by the surrounding pieces, much smaller than they are; the second is irregularly shaped, about the size of the subradials, and bears upon its upper edge an arm.

We have never been able to procure a specimen which had a vault preserved, and can therefore give no description of it. We doubt the existence of a proboscis. The figure* is drawn the size of nature.

Arms.—Following the large first radials are three small, rounded pieces, two quadrangular, the third axillary, giving off two branches, which are long, tapering, composed of a single row of stout pieces; three branches give off at intervals on either side, long filamentous pinnulæ, which extend the full length of the arms. These are composed of small pieces resembling those forming the arms, and are similarly arranged. There are five pairs, rising from the regular rays. From the anal field rises a single, long, tapering arm, not bifurcated as the others are.

* To be given hereafter.

None of the family of Cyathocrinidæ have yet been described in which the anal field always bore an arm. We supposed at first that this sixth arm was only an anomalous condition of the individual, but having in our possession six or seven specimens, all showing this arrangement, its actuality is placed beyond cavil.

Hall has described (Iowa, vol. ii, p. 625, pl. 18, fig. 7, 8,) *C. spurius*, to which our species is most closely related; it differs in the sixth arm, which alone constitutes it a distinct species. See also *P. Meekianus*, Shumard (Geol. Rep. Missouri, p. 188, pl. A, fig. 7, a, b).

Geological Position and Locality.—Found in sub-carboniferous beds of Clear Creek, Hardin county, Ky., and Montgomery county, Indiana.

Actinocrinus Indianaensis, nobis.

Calyx, subglobular, ornamented with hieroglyphic sculpture. Proboscis long and thin, arms very long, articulations similar in size.

Basal pieces, three; large, extending beyond the supra columnar oint. The margin of the basis projected into a flange.

Radial pieces, 5×3; the first is large, heptagonal, its central portion marked by a double sigmoid carina; its upper facet is angularly notched, into which depression the second radial pieces fit; they are longer than wide, pentagonal, supporting the third radials, which are axillary. These last give off on either facet two radials of the second series, the last of them axillary, and support two rows of three brachials each, the last ones of which are large, tumid, and quite protuberant; here the free arms come off. This is the case except in the antero-lateral ray, where the radials of the second series support only one row of brachials on each beveled edge, thus giving $4\times4+2=18$ pairs of arms.

A prominent carina commencing on the first radial piece extends over the middle of all the pieces, distinctly marking the ramifications of each ray.

Interradials.—Three are interposed between each two rays, except of course, on the anal side, (a large hexagonal one followed by two smaller ones) their middle portions rise into mammiform protuberances.

Anal pieces, seven; hexagonal, of nearly the same size. First one, followed by a row of three, then two; above them a single one, which completes the pyramid. The ornature of these pieces is the same as that of the interradials. We have one specimen showing elaborate hieroglyphic markings; doubtless this was the character of the original ornature of the surface.

Vault—about equal in size to the calyx, composed of many small polygonal pieces, which are intumescent, sometimes prolonged into small sharp thorns. The whole is surmounted by a thin, long proboscis, composed of very minute pieces, and closed at its extremity, where it widens out into a fusiform shape.

Arms.—When in a normal condition there are eighteen pairs of arms, long, dividing into two branches almost immediately after leaving the brachials, each branch running out to the end without further bifurcations. They are formed of a double row of pieces, which at their juncture present a serrated appearance; towards their outer extension they become gradually smaller, until at their end they are quite attenuate and generally curved inward. They are deeply sulcate on their inner surfaces,

and bear on their lower outer edges long filamentous frimbriæ, which are set closely together, one to each piece forming the arm; these are composed of five or six joints, each having a direction outwards or downwards. *De Koninck and Le Hon* figure (Recherch. Crinoid. foss., Pl. IV, fig. 3,) a bundle of arms which so nearly resemble the arms (with head attached) of one of our specimens, that we cannot but regard them as perfectly identical. They refer them to *Actinocrinus stellaris*, to which species they certainly do not belong. A *stellaris* has 20 arms, (our species 18) arranged in 5 rays of 4 each, with comparatively large interstitial spaces, while the arms figured are thickly crowded together, coming off as they did in almost a closed circle, without any interstices of moment to divide them into separate bundles of arms.

Geological Position and Locality.—Sub-carboniferous beds of Montgomery county, Indiana. It is quite an abundant fossil, and generally found in a good state of preservation.

Actinocrinus Coreyi.

Body, globular; the vault about one third higher than the calyx; tumid; vault surmounted by a large knob.

Basal pieces, three; forming together an irregular hexagon, scooped out, producing a depression occupying about one-half of the superfices.

Radials.—The first are large, irregularly hexagonal, wider than high; their upper surfaces are hollowed, receiving the second radials, which have a corresponding convexity; they are thin but wide, flabelliform, and bearing the third radials, which are flattened pentagons, axillary, and support on each beveled edge three unsymmetrical brachial pieces, five or six times wider than high; thence the free arms.

Interradials, three; the first is very large, generally an elongated octagon; above this are two irregular, thin, high pieces, each having a small depression near the center of their lower surfaces, and interposed between the arms.

Anal pieces, seven; the first is large, having a depression corresponding to that described in the radials; in a row with the first radials, but a little larger than them, hexagonal, its vertical diameter is greatest on its three upper facets, bearing three pieces; they are smaller than the first anal piece; the one on the superior facet is irregularly hexagonal, the lateral ones are long, rather unsymmetrical, and adjoining the neighboring radials and brachials, which nearly enclose them; upon these are three considerably smaller polygonal pieces, which complete the calyx. All of the pieces described above are tumid, without any visible external markings.

This intumesence renders the sutures of the pieces very marked. The arms are ten in number, very strong and thick, coming off in five pairs; we cannot describe them farther, as they are not preserved, and this is the only example we have of this species.

Vault.—The vault is surmounted by a very prominent knob, from which are projected in the directions of the arms, five plicatures, formed of four or five (generally four) massive tumerous pieces; they are much larger than any of the other pieces of the vault, with the exception of the central knob. Between each two of the plicatures is an interradial field, containing from eight to ten polymorphous pieces; they are generally ar-

ranged in a pyramidal form; often the vertex being a piece considerably larger than any of the others; the basal pieces of the pyramid are in most cases thinner and longer than any of the others; these, as well as the remainder of the pieces of this species, are turgid and massive, and like those of the calyx, are destitute of ornament.

On the side of the vault, above the anal field, is a considerable ovoid intumescence, composed of nearly thirty small pieces, whose surfaces are quite plain and level in contrast to the other pieces of the vault; they are arranged in nearly parallel rows, as follows, commencing with the lowest: 1-3-4-5; on the fifth row (which nearly completes this field—there are but two more rows) supervenes an ovoid opening, about one line in length, without a proboscis. This is the only opening upon the vault.

We have named this elegant species after Mr. O. W. Corey, to whom we are much indebted for many favors.

Dimensions.

Diameter of base,	·32 inch.
Greatest diameter,	1·30 "
Height to arms,	·35 "
Total height of body,	1·10 "
Diameter of axillary articulation,	·30 "

Geological Position and Locality.—Rare in sub-carboniferous limestone near the top of the knob stone bed, Hardin and Allen counties, Ky., and same geological horizon, Washington county, Indiana.

GENUS ONYCHOCRINUS, nov. gen. *Lyon & Casseday.*

Generic Formula.

Basal pieces,	3
Subradial,	5
Radial,	5×5
Brachial,	4 or 6×5
Interradial,	20 or 25×4
Anal,	5 to 7
Interaxillary,	1 to 3×5
Arms,	5 pairs.

Generic description.—This genus, in the shape of some of the pieces and in its general form, resembles more closely *Forbesiocrinus* than any other; yet they are so widely different in other respects that it will require no great perception to distinguish between them. The column near the calyx is cylindrical, large, composed of very thin articulations similar in size to each other; perforation small.

The radials are large, and form, together with the brachials, a continuous line: the arms are quite robust, furnished with strong pinnulæ.

Interradial fields, triangular in general shape; an anomalous one on the anal side. Anal field—long and narrow: one to three small interaxillary pieces on each ray.

Basal pieces small, subradials large, pentangular, alternating with the radials.

Onychocrimus exculptus, n. s.

Calyx vasiform, spreading rapidly to the base of the free arms, together with the arms resembles much the talons of a bird, whence its generic name; surface ornamented with minute granules.

Basal pieces, three; their under surfaces concave, forming a saucer-shaped depression, which was wholly filled by the column; they are low, rather thick, upper surfaces prolonged into an obtuse angle; the column facet marked by small short striæ on the outer margin.

Subradials, five; large, four are pentagonal, two of which are larger than the remaining two; their upper articulating surfaces form quite sharp angles; the fifth is hexagonal, its superior surface parallel to the inferior, smaller than the remaining pieces.

Radials, generally five in each ray; the first row are very large, heptagonal, except in the postero-lateral rays, where they are hexagonal, having but one facet on the side next the first anal piece instead of two; their lower surfaces rest on the retreating angles formed by the subradials, with which they alternate; their superior margins are horizontal, on which are imposed the second row of radial pieces; these are smaller than the first, hexagonal, nearly twice as wide as high. The third and fourth rows are similar in form, but become gradually smaller; the fifth rows are heptagonal, axillary, and support on each beveled edge a row of two or three brachials, which are smaller than the radials, obscurely hexagonal, bounded by wave-like lines; near the center of their inferior borders they are prolonged into minute uvulæ, or little tongue-like projections, similar to those found in some species of *Forbesiocrinus*, (and described by Hall as patelloid pieces,) which fit into corresponding depressions in the adjoining pieces.

Upon the last brachial pieces rest two arms; they are as long as the body, robust, composed of exceedingly stout pieces, grooved by a deep sinus, decreasing gradually in size to their outer extension; they are similar in form to the brachials described above; from either side of these arms, alternately disposed, are stout, short pinnulæ, composed of thick pieces stretching in a direction outwards and upwards, without tentaculæ. Commencing with the first two pieces of the arms, they come off in two pairs, then on the next two pieces come off again two pairs, but on the alternate side from the first two; this arrangement is continued throughout their whole length, the pinnulæ becoming smaller and more closely crowded together toward the termination of the arms.

Interradials.—These vary from twenty to twenty-five, according to the age of the individual. The first is large, septagonal, situated between the first two radials of each row, followed by three pieces about half the size of the first; the middle piece of the three is an elongated pentagon, smaller than the other two, which are hexagonal, upon the outer upper facet of each of which, and lying against the radials, are one or two smaller pentagonal pieces; then follow (in the specimen we have before us) fifteen yet smaller pentagonal pieces; they are arranged in the form of a hemispherical arch, depressed towards the disc of the stomach, the sides of the arch being extended up along the radials and brachials as far as the commencement of the free arms.*

* See also under description of Vault.

Interaxillaries.—In a line with the radial, and between the two opposite arm pieces, is one to three quite small pentagonal interaxillary pieces; sometimes two yet smaller pieces occur.

Anal pieces, one; small, quadrangular; one is superimposed on the subradial, followed by three pieces of like form and size, and similarly disposed.

Vault.—The vault of this remarkable crinoid resembles so much some of the *asteriada* that we may consider it as one of the connecting links between the crinoidea and the star-fishes. The specimens in our possession do not show distinctly the whole of the vault, so that a description must necessarily be imperfect until better examples are found. The plates which we have described above as interradials, form the greatest portion of the perimeter of this upper surface; the remainder of the perimeter is formed of a row of pieces lying on the anal side; their relative position is as follows: viewing it from the anal side, in the position in which the animal grew, we see a row of small pieces (interradials?) which extend up along the radials and brachials of the left ray, fitting into the serrated depressions existing at the junctures of any two pieces. This is found only on the left ray, the pieces forming the right being squarely truncated and without other pieces attached in any way to them.

The general surface of the vault is depressed, the edges being raised and curved inwards. From the centre, and in the direction of the arms, extend five rays, composed of two rows of large granular pieces, one row alternating with the other. We cannot discover pores in any of these pieces, which are most probably analagous to the *ambulacra* of the *asteriada*.

The interstitial pieces lying in the fields bounded by the five rays of larger ones are very small, granulose, and arranged without any apparent order.

It is impossible, from the fragmentary portions in our cabinets, to trace the farther similarity between this genus and the star-fish, as the central portions of all are so concealed that we cannot make them out clearly.

Geological Position and Locality.—Found at Clear Creek, Hardin county, Ky., in sub-carboniferous rocks near the upper part of the sandy mud-beds of the knobstone. In beds of similar age in Montgomery county, Ind. Good specimens are rare.

Louisville, Ky., Nov. 1, 1859.

ART. X.—*Theoretical Determination of the Dimensions of Donati's Comet;* by Prof. W. A. NORTON.

I HAVE recently undertaken to bring the theory developed in a previous number of this Journal,* in an article entitled "Dynamical Condition of the Head of a Comet," to the test of numerical computations, by determining, by calculation, the theoretical dimensions of the great Comet of 1858. The more important results may be briefly stated; the complete discussion is reserved for a subsequent number of the Journal.

* Vol. xxvii, [2], 86.

It appears from the investigation that, confining our attention to the outer bright envelope, the process of ejection of nebulous matter from the nucleus was mostly confined to a certain portion of its illuminated side lying nearest to the sun, and that the limiting angle of inclination of the jets to the line connecting the centre of the nucleus with the sun, was 25°. From this circumstance it resulted that the envelope had nearly a circular form. The lateral dispersion of these luminous jets, as they were flowing away into space, under the influence of the sun's repulsion, or, in other words, the breadth of the tail, was partially due to the directions, more or less inclined to the radius vector, in which they originally issued from the nucleus; but another and highly efficient cause coöperated to produce that result. If, as we conceive, certain portions of the cometic matter, at the surface of the nucleus, were brought by some action of the sun into the condition to be repelled by both the nucleus and sun, we may make two suppositions with regard to the forces of repulsion thus developed; that the force exerted by either body was of the same intensity for all the particles acted upon, or that it varied from one particle to another. It is not easy to decide, upon *à priori* grounds, which of the two suppositions is the most probable. The latter is certainly no less so than the former. If we adopt this as a fundamental hypothesis, we have an efficient cause in operation adequate, in connection with that already mentioned, to the development of the tail of the comet, in all its vast proportions; and which may incidentally have produced the special phenomena observed,—as the supernumerary tails, and the alternate bright and dark bands seen to traverse a certain portion of the principal tail. The ejected particles that are unequally repelled, by both the nucleus and sun, do not part company in consequence, while they are in the vicinity of the nucleus, nor materially while within the limits of the envelope, for the reason that the ratio of the repulsive forces of the two bodies remains constantly the same; but as soon as they pass out of the sphere of influence of the nucleus they are analyzed by the solar repulsion, and driven off by it into space, in separate and diverging paths. The various susceptibilities to repulsion possessed by the particles have accordingly no sensible effect upon the dimensions or form of the envelope, but may give rise to a wide lateral dispersion of the flowing streams that make up the tail of the comet. The particles that are most energetically repelled go to make up the preceding or convex side of the tail.

I have made the calculations, regarding the solar repulsion as varying between certain prescribed limits. The determinations of the breadth of the tail, at various points of its length, accord with the results of observation; at the same time that the tail is found to have the form and positions actually observed.

The supernumerary tails observed were but lines of receding

particles subject to much greater forces of repulsion than the other particles ejected from the nucleus. All such collections of matter would, of necessity, be in advance of the principal tail, and lie in a curve that would approach more nearly to a straight line. Their position makes known the intensities of the repulsive forces to which they owe their separate existence.

An interesting result of the investigation is that the alternate bright and dark bands so distinctly seen to traverse a certain portion of the tail of Donati's comet, in nearly parallel directions, on the evening of Oct. 10th, had each the position of a line connecting particles which started from the region of the nucleus at a certain previous date, and at the same instant of time. They accordingly find their natural explanation in corresponding alternations in the quantity of nebulous matter given off simultaneously from the nucleus. The most probable cause for such alternations of discharge that can be conjectured is that the nucleus turns about an axis, and so presented periodically different sides to the sun, which were unequally influenced by his inciting action. If this be the true explanation of the phenomenon, we have in the observed distance between contiguous bright bands, the means of determining the period of rotation; or, at least, the shortest interval of time in which the rotation can be completed. If we take this distance at 1°, the period of rotation comes out about 24 hours.

There was a special cause of lateral dispersion at work in the case of the cometary particles that, on their return, came very near the nucleus. Such streams of particles must have been repelled off obliquely, and may very well have presented the appearance of luminous jets issuing from the sides of the nucleus, and have formed curved terminations to the inner envelope. From the dispersion thus produced resulted an absence of matter, or a dark space, behind the nucleus, whose varying boundary was determined by the intersections of lines of particles unequally repelled by the sun.

The indications are, that the formation and gradual expansion of one envelope after another, may have arisen from the process of ejection beginning in all instances high up in the photosphere surrounding the nucleus, and gradually extending downward to the vicinity of the solid surface. It appears, upon investigation, that if this descending action were to proceed according to a certain uniform law, the outline of the envelope would recede from the nucleus at a uniform rate. This process of evolution of cometary matter, in whatever it may consist, is probably auroral in its origin and character, and has its counterpart on both the earth and sun.*

New Haven, Nov. 30, 1859.

* To render the investigation more complete, I have considered the case of the cometary matter being projected from the nucleus, without experiencing any repulsion from its mass.

Art. XI.—*Geographical Notices.* No. X.

The Mountains of Western North America.—Having previously spoken of the publication of Warren's memoir to accompany the map of the western territory of the United States, and also of the map to which it refers, we now copy the following paragraphs from the conclusion of the Memoir, in order to meet the erroneous opinions which are prevalent in respect to the "Rocky Mountains," and the erroneous presentation of their direction which is given in most of the popular maps.

"The mountains in our territory west of the Mississippi river, from where they rise above the horizontal strata of recent geological formations on the east to their disappearance under the waters of the Pacific Ocean, form a nearly continuous mass of upheaved ridges, with occasional intervening level plateaus. The direction of the central line of this mass between the 32d and 49th parallels of north latitude, is about north 20° west. The greatest width perpendicular to this direction is along the line passing from the vicinity of San Francisco through that of the Great Salt Lake to Fort Laramie. This distance is about 1,000 miles, or, if we include the Black Hills of Nebraska, 1,125 miles.

"The great mountain mass, of which that in our territory forms but a part, extends with varying breadth nearly on the line of a great circle of the globe from Cape Horn north to Behring Straits, and thence south along the western part of Asia to the island of Sumatra. Its length is about 240 degrees, or 18,560 miles, being two-thirds of the circumference of the earth.

"The area occupied by and included in this mountain mass in our territory, is about 980,000 square miles. Large as this is, it is probably only a small portion of the upheaved formations between the 32d and 49th parallels. A few ridges and peaks projecting above the surface of the Pacific as islands, or above the level tertiary and cretaceous strata of the eastern plains, give evidence of the existence of vast areas whose extent must forever remain unknown. Throughout the portions now visible, proofs are abundant of great abrasions; in some cases whole ridges even, having been swept away or broken into separate portions.

"Already enough has been learned to establish the existence in these mountains of the equivalents of many of the geological formations; and it is probable, when investigations have been carried to the same extent as in the civilized portions of the earth, that the geologist will find here new and still more complex fields for research.

"The classification of the separate parts of this mountain mass, so as to present its physical characteristics clearly to the

mind, is a great desideratum. It has in part been attempted at various times, but as yet unsuccessfully from the want of sufficient information; the theorist's idea being often proved to be wrong by new discoveries almost as soon as uttered." * * *

"The publication of the Pacific Railroad maps will probably change some of the former ideas of these mountains, and give rise to new speculations as to their directions, equivalents, and connexions of different parts. Every one knows how easy it is to generalize ideas where facts are few, and in accordance with this, those who have travelled most in the region have theorized the least, having seen the immensity of the subject and the difficulties which must be overcome to comprehend it. Those who have investigated merely the travels of others, have had only the imperfect representations of the latter on which to theorize.

"It may not be inappropriate here to give some of the general ideas which have successively prevailed in regard to these mountains.

"In the earlier periods of North American discovery it was known that there were mountains in the interior at its northern and southern parts, and rivers flowing from them to the two great oceans east and west. It was natural to connect these mountains by hypothesis, and to consider them as one great chain, separating the sources of these streams. Such an idea prevailed at the time of Humboldt's New Spain. Even now many well informed persons consider that a road has but one mountain summit to cross from the Mississippi river to the Pacific Ocean.

"When, after the publication of the charts of Vancouver, map makers became aware of the extent of the mountains near the Pacific coast, nothing seemed more natural than to suppose two great mountain chains—one near the Pacific and one in the interior. If this theory were true, we should find a great longitudinal valley between the ranges similar to that separating the interior mountains from the Alleghanies, and we should have but two mountain summits to pass between the Mississippi and the Pacific. This idea is practically as erroneous as that of one summit, although it still prevails. Such a prominent place did this longitudinal valley hold, in the opinions of geographers of earlier times, that we find in Humboldt's New Spain: 'M. Malte Brun has started important doubts concerning the identity of the Tacouche Tesse and the river Columbia. He even presumes that the former discharges itself into the Gulf of California: a bold supposition, which would give the Tacouche Tesse a course of an enormous length. It must be allowed that all that part of the west of North America is still but very imperfectly known.'

"The explorations of Lewis and Clarke proved that the Tacouche Teche did not empty into the Gulf of California, and

that it was probably the source of the Columbia. Without considering the character of the pass of the Columbia river through the Cascade range, the belief now became general that the overland route in this latitude crossed but one summit, and was therefore more favorable than any other. This erroneous idea with some still prevails.

"The idea of rivers traversing great mountain chains, now known to be so common in the mountains west of the Mississippi, was so repugnant to the opinions of even philosophers in earlier times, that we find Humboldt saying, 'every geographer who carefully compares Mackenzie's map with Vancouver's will be *astonished* that the Columbia, in descending from the Stony mountains, which we cannot help considering as a prolongation of the Andes of Mexico, should traverse the chains of mountains which approach the shore of the great ocean, whose principal summits are Mount St. Helen and Mount Rainier.'" * *

"The distinguished explorers, Lewis and Clarke, having determined that the Columbia river broke through the Cascade range, considered from the size of the Willamette at its mouth, that it also broke through this chain, having its source in the Rocky mountains, near the position of the Great Salt lake. We then see the American maps representing mountains surrounding the valleys of the Columbia and Colorado, and separating them from that of the San Joaquin and Sacramento. On the English maps of that date, the Sierra Nevada is not represented, and two or three great rivers are made to flow from large lakes in the interior to the Pacific; nearly all of their compilers making false applications of the principles of hydrography laid down by Humboldt.

"The first map which represented these rivers and lakes correctly was that of Captain Bonneville, of which I have given a reduced copy. There we see the Great Salt lake and Bear river and Utah lake forming one basin; to the west lies the Mary or Ogden's river, with its lakes forming another enclosed basin; the San Joaquin and Sacramento rivers in their right position; and the Willamette reduced to its proper length. The positions given on this map are not geographically correct, nor are their many mountains indicated; but it gives the first correct idea of the hydrographic character of the country; and by giving too little rather than too much, escapes the errors into which others had fallen.

"The explorations of Captain Frémont fixed these great rivers and basins in their proper geographical positions; but his maps have given rise to many erroneous impressions in regard to the mountain ranges. Still, making a 'false application of the principles of hydrography,' he represented all the basins as if surrounded with mountains or 'rims,' and thus introduced mountain chains which have no existence in nature.

"Since Frémont's expedition began, a large portion of the area of these mountains in the territory of the United States has been examined, and many new attempts have been made to systematize the knowledge acquired. The most important theory advanced is that of parallelism in the ranges, the foundation of which I shall briefly indicate.

"On the map of Lewis and Clarke the Rocky mountain ranges are represented parallel to each other with a northwest trend. That this was their theory is evident, from the fact that they indicated the Black Hills about the source of the Shyenne as having this same trend, though they never saw them, and only knew of their existence from hearsay.

"The maps of Captain Frémont showed a parallelism and general north and south direction of the mountain ranges from the Wasatch, east of the Salt Lake, to the Sierra Nevada, including all the numerous intermediate ranges.

"The maps made by Major Emory, near the 32d parallel, and in New Mexico, showed again a remarkable parallelism of the mountain ridges, those in this latitude having a northwest trend nearly parallel to the Rocky mountains, as shown by Lewis and Clarke.

"The maps of Lieutenants Abert and Peck, of Lieutenant Simpson, of Lieutenant Beckwith, Lieutenant Williamson, and Lieutenant Parke, have all shown a local parallelism to exist in different parts of the mountains. The systems of ridges have courses varying from a few degrees north of east to north 45° west.

"The idea has lately begun to prevail that this local parallelism is the characteristic of the great mountain mass throughout its whole extent. Whether this idea has been true or not it has been attended with some practical advantages. Instead of one or two main summits for an overland road to pass, it shows us that we must expect many. On every route explored across the continent, at least four well-defined summits have been discovered, and on some of them many more. Some of these ridges enclose interior hydrographic basins. Others are traversed by rivers, but the passes thus made are generally impracticable, and, for the purposes of travel, might almost as well never have existed.

"In many places, however, the mountain ridges have not this local parallelism, of which a few instances will be cited. The Uintah mountains, east of the Great Salt Lake, trend nearly east and west; the Wind River mountains about north 45° west; and the Humboldt range about north 20° east; these three ranges being comparatively near to each other.

"Humboldt, in speaking of the Sierra Nevada, says, 'it soon separates into three branches.'

"Lieutenant Abbot, in the sixth volume of the Pacific Railroad Reports, says: 'Shasta Butte, although generally considered a peak of the western chain of the Sierra Nevada, is, in truth, the great centre from which radiate, beside several smaller ridges, the Cascade range, the Coast range, and the western chain of the Sierra Nevada.'

"There are many other portions of this mountain region from which the ridges seem to radiate. Such as Long's Peak, the junction of the Sierra Nevada, and Coast ranges in Southern California, &c., as is evident on an inspection of the map. The parallel system of ridges has been considered a matter of importance, as being in accordance with some supposed laws of mountain formation, but that of centres of upheaval are not less consistent with those laws. At any rate it does not appear that we are at liberty to assume a parallelism of ridges till examination has shown this to be the case.

THE SOURCES OF THE NILE.—At a recent meeting of the Royal Geographical Society of London (May 9), Captain Speke gave the following narrative of his journey with Capt. Burton into the interior of Africa. His remarks were called out by a paper of Mr. Macqueen's, the object of which had been to prove that the mountain Kilimandjaro is actually snow covered but that it has no connection with the River Nile.

Capt. Speke's remarks are thus reported in the Proceedings of the Society, vol. iii, No. 4:

"After arriving at Zanzibar, we had to wait a considerable time, some months, until the masika, or rainy season, would be over, before we could penetrate into the interior. It was generally advised that we should do so. During the interim Captain Burton and myself made a short coast tour, first to Mombas, and then proceeded down the coast to Pangani. Leaving that place, we ascended the Pangani river, and arrived at Chongwe, a small military station belonging to Prince Majid. Here we were supplied with a small escort of Belooch soldiers, who accompanied us across some hills, by an upper route, to Fuga, the capital of Usambara, where we were hospitably entertained by King Kimwere, a great despot reigning there. After visiting him for one day, the shortness of our supplies compelled us to retrace our steps by a forced and rapid march, following down close along the banks of the same river until we again arrived at Pangani. Thus ended our initiatory tour in Eastern Africa. The rainy season or masika was spent by us at Zanzibar, in constructing the equipment of a caravan. There is a singular tribe of negroes in the interior of Africa, called Wanyamuezi—the literal translation of which signifies people of the moon. These strange people are professionally voluntary porters: they annually bring down ivory to the coast in barter for themselves, or otherwise

for the Arabs. At the close of the rainy season Captain Burton and myself left Zanzibar, with a caravan mustering about eighty men, having previously sent on some supplies in anticipation of our arrival. Unable to collect a sufficient caravan for the conveyance of our kit, we purchased a number of donkeys (about thirty). Thus completed, and with an escort of twelve Belooch soldiers, given us by Prince Majid, we commenced our journey westward, and arrived (by slow degrees travelling over a low alluvial plain, up the course of the Kingani river) at Zungomero, a village situated under the coast range, which struck us as bearing a good comparison with the western ghauts of India. We might call this range the Eastern Ghauts of Africa. There we were detained by severe illness a considerable time. Afterwards we crossed these eastern ghauts, the maximum altitude of which I ascertained to be about 6000 feet. On the western side of this longitudinal chain of hills we alighted on an elevated plateau, an almost dead flat, ranging in level from 3000 to 4000 feet above the sea. Here we had cold easterly winds, continuing through the entire year. Proceeding onwards, we arrived at the Tanganyika Lake, called by the Arabs Sea Ujiji, a local name taken from the country on the eastern margin of the lake, whither they go to traffic for ivory and slaves. This lake is in a singular synclinal depression; I found its elevation to be only 1800 feet; whereas the surrounding country (the plateau), as I said before, averaged from 3000 to 4000 feet. The lake is encircled at its northern extremity by a half-moon shaped range of hills, the height of which I estimated (for I could not reach its summit) to be at least 6000 feet. They may extend to a height much greater than that; however, we could not take any observations for determining it. After exploring this lake we returned by the former route to Unyanyembe, an Arab depôt, situated in latitude 5° south, and about 33° east longitude. My companion, Captain Burton, unable to proceed farther, remained here; whilst I, taking just sufficient provisions for a period of six weeks, made a rapid march due north, to latitude 2° 30′ south; and there discovered the southern extremity of the Nyanza, a lake, called by the Arabs Ukerewe, a local name for an island on it, to which the merchants go in quest of ivory. The altitude of this lake is equal to the general plateau (4000 feet), even more than the average height of all the plateau land we traversed. In reverting to the question asked, why I consider the Lake Nyanza to be the great reservoir to the Nile, my answer is this: I find, by observation, that its southern extremity lies in east longitude 33°, and south latitude 2° 30′. By Arab information, in which I place implicit confidence, I have heard that the waters extend thence, in a northerly direction, certainly from five to six degrees. Notwithstanding they can account for

a continuous line of water to this extent, no one ever heard of any limit or boundary to the northern end of the lake. A respectable Sowahili merchant assured me that, when engaged in traffic some years previously to the northward of the line and the westward of this lake, he had heard it commonly reported that large vessels frequented the northern extremity of these waters, in which the officers engaged in navigating them used sextants and kept a log, precisely similar to what is found in vessels on the ocean. Query, Could this be in allusion to the expedition sent by Mahamad Ali up the Nile in former years? Concerning the rains which flood the Nile, the argument is simple, as I have said before: a group of mountains overhang the northern bed of the Tanganyika Lake. The Arabs assure us that from the north and northeastern slopes of these hills during the rainy season immense volumes of water pour down in a northeasterly direction, traversing a flat marshy land, intersected by some very large, and many (they say 180) smaller streams. Again, on the western side, we hear from Dr. Krapf, that the snow-clad mountain, Kœnia, is drained by rivers on its western slopes in a direction tending to my lake.

"During the rainy season, which I know, by inspection, commences in that region on the 15th of November, and ends on the 15th of May, the down-pour is pretty continuous. Supersaturation, I should imagine, takes place later on the northern than on the southern side of the aforesaid moon-shaped mountain, systematically in accordance to the ratio of seasonal progression; but this, in so mean a distance, could not be very great. Suffice it to say, that I saw the Malagarazi river, which emanates from near the axis of these hills, to be in a highly flooded state on the 5th of June. The Nile at Cairo regularly swells on the 18th of June.

"Farther, it would be highly erroneous to suppose that the Nile could have any great fluctuations from any other source than periodical rains. Were the Nile supplied by snow, as some theorists suppose, its perennial volume would ever be the same. There would be no material fluctuations observable in it, in consequence of its constant and near approximation to the path of the sun.

"By these discoveries, the old and erroneous hypothesis of a high latitudinal range of mountains extending across the continent of Africa from east to west, in the vicinity of the line, and known as the Mountains of the Moon, is therefore now annihilated. However, it is worthy of remark, that the crescent-shaped mountain, which we visited to the northward of the Tanganyika, lies in the centre of the continent of Africa, immediately due west of the snowy peaks Kilimanjaro and Kœnia, and is west beyond the Unyamuezi, or Country of the Moon.

The Wanyamuezi tribe has from time immemorial been addicted to journeying, and at all periods has constantly visited the eastern coast of Africa. It would not be beyond legitimate and logical supposition, to imagine that these hills, lying beyond their Moon Country, should have given rise to the term Mountains of the Moon, and from misunderstanding their relative position with the snowy Kœnia and Kilimanjaro, should have been the means of misguiding all ancient inquirers about that mysterious mountain.

"My positions were fixed by astronomical observations, certainly under painful and considerable difficulties, owing to my constantly impaired general state of health: weakness and blindness not being the least of these difficulties which I had to contend with. My latitudes were taken by the altitude of stars, at nearly every stage, on an average from ten to fifteen miles apart. I also fixed some crucial stations, the principal points for delineating the country by lunars, on which I place great reliance, as the means of the masses of them which I took show so little deviation. The intermediate distances I compassed very closely; the altitudes of the country I traversed I determined by boiling thermometer, on which I also place very great reliance. We had a thermometer and pedometer, and several chronometers. The performance of these instruments was anything but satisfactory; indeed, finally, I had to rig up a string and bullet pendulum to beat time whilst taking my lunars in the latter stage of the journey. There now can be no doubt that this great lake, the Nyanza (Captain Speke now pointing to the map) is the great reservoir of the Nile, and that its waters indubitably extend northwards from the position visited by me on its southern extremity to $3\frac{1}{2}°$ north latitude, lying across the equator, and washes out that supposed line of mountains, called the Mountains of the Moon, which stands so conspicuously in all our atlases."

Baikie's Niger Expedition.—The latest intelligence we have received from this important expedition is contained in the following extract from Sir R. I. Murchison's late anniversary address before the Roy. Geog. Soc. of London:

"The unfortunate shipwreck of the *Pleiad* on the rocks near Rabba, and the check given to the expedition under Dr. W. B. Baikie, which left England early in 1857, were alluded to in my last year's address. I now learn from Mr. D. T. May, R.N., who has returned to England, that less than twenty miles above Rabba the River Niger, or Quorra, divides into several rocky, intricate channels. Consul Beecroft in the *Ethiope*, in 1845, safely navigated the most available of these passages; but the voyagers of 1857 were not so fortunate, and the steamer was totally lost on the rocks. Most of the property was, however,

saved, and the neighboring bank became the head-quarters of the expedition for a whole year. The rocks forming the banks of the river where the shipwreck took place are composed of highly-inclined strata of hard sandstone. All the specimens of this rock which I have examined, whether brought home by Mr. May or sent by the Admiralty, belong to the same light-colored, hard, sub-crystalline, pinkish sandstone, with very fine flakes of white mica; the successive layers (which are much foliated) being strikingly covered by thin elongated crystals of black tourmaline. The rock has altogether the appearance of having undergone considerable metamorphosis, and much elevation and disturbance. Geodes of pure white quartz, with large micaceous coatings, also occur. As soon as the party had become somewhat settled, it was determined to make a direct overland communication by Yóruba with Lagos, and Mr. May offering himself for this service, accomplished it satisfactorily, as explained in a notice laid before the Society. In the mean time Lieut. Glover made journeys up the river, visiting Wawa and Busa, and definitely ascertained the impracticability of navigating the river for a few miles beyond the spot of the encampment, a waterfall at Waru being an impassable barrier even for canoes in any season.

"Mr. May having waited on the sea-coast, expecting another steamer from England, at last returned to the encampment through Yóruba, and then set out on a more extended journey, with a view to exploring the country, and of establishing postal communication in a line from Lagos to the confluence. Having first travelled to Hadan (the road between Lagos and Hadan being well known and used), he passed eastward, and journeyed for many weeks through the previously unvisited districts of Ife, Ijesha, Igbouma, Yagha, &c., being warmly received, and observing everywhere that the people were quiet, orderly, and industrious; though these good qualities are here and there broken in upon by marauding or slave-catching armies, sent into the Yóruban country by powerful neighbors. The details of this journey were communicated to the Foreign Office in January last, and will, I presume, soon reach the Society.

"Approaching to within fifty or sixty miles of the confluences of the Quorra and Chadda Rivers, Mr. May was compelled to alter his route, and proceed northwards, visiting the ruined famous town Ladi, crossing the Quorra at Shaw, and journeying thence on the north side of the river through Núpe to Rabba.

"Lieutenant Glover had during this time also visited the coast by Mr. May's first route, and was now there waiting to pilot up the river the steamer which was at last coming to the relief of the party. Dr. Baikie and the other members of the expedition had been chiefly employed during the year in culti-

vating a good understanding with their neighbors, reducing their language, &c., whilst the energies of Mr. Barton were amply occupied on the botany of this part of Africa. In October, 1858, just a twelvemonth after the settlement of the expedition at the spot in question, the *Sunbeam* steamer arrived, the whole party were then embarked, and proceeded down the river to Fernando Po, there to recruit the health of the officers and men, and make arrangements for farther exploration. During the twelvemonth's residence in Núpe the most friendly relations were maintained with the king, his brother, and chiefs, and the natives generally; supplies being often received overland from Lagos.

"At Fernando Po (November, 1858), a re-organization having taken place, and the preparations being completed, the party again set out, now in the steamer *Rainbow*, built and sent for the purpose, and endeavored to re-ascend the river. But it was then found that this vessel, which draws four feet of water, could not ascend the Niger even in the month of January; the waters subsiding until June, when they increase. In consequence, the party was obliged again to return to the sea, and since have set out upon the land-journey from Lagos to Rabba (upon the route opened up by Mr. May), whence it is purposed to proceed with an expedition, the friendly objects of which must by this time have made a due impression on the native chiefs, and from which we may anticipate the gain of much knowledge when all the acquisitions of Dr. Baikie and his associates are unfolded."

Khanikoff's Expedition in Central Asia.—At a recent meeting of the American Oriental Society in New York, the Corresponding Secretary, Prof. Wm. D. Whitney of Yale College, presented a letter from the Chev. N. Khanikoff, dated Kerman, Persia, April 7–19th, 1859, in which he speaks as follows of the journey which he has just made.

"I have just completed, or nearly so, a very interesting journey through Khorassan, Western Afghanistan, and Northern Seistan. The whole region traversed by the scientific expedition which I have had the honor to conduct has been carefully surveyed, the situation of its principal points has been fixed astronomically, for more than thirty points ascertainment has been made of the magnetic coördinates, and of the intensity of magnetism corresponding therewith, and the profile of the territory has been determined by barometrical observations and trigonometrical measurements. The botanical researches have been made by Prof. Bunge, and the geological investigations by M. Göbel; the oriental literature, archæology, and numismatics have fallen to my share, and I hope soon to have the pleasure of communicating to the Society a succinct view of the results at which I have arrived." D. C. G.

Art. XII.—*The Great Auroral Exhibition of August 28th to September 4th*, 1859.—(2d Article.)

In our last Number* we gave some observations of this grand auroral exhibition, from a number of stations widely distant from each other. We now put on record some facts observed respecting the influence of the Aurora upon the wires of the electric telegraph. We hope in our next Number to be able to communicate additional intelligence respecting this Aurora.

1. *Observations made at Boston, Mass., and its vicinity by* George B. Prescott, *Telegraph Superintendent.*

My attention was first called to the possibility of the Aurora Borealis affecting the telegraph wires in 1847, while operating the Morse (electro-magnetic) telegraph at New Haven; but I was not fortunate enough to observe it until the winter of 1850. At this time I became connected with Bain's (electro-chemical) telegraph in this city, and observed some effects of the aurora; but, owing to the feeble displays, only to a limited extent.

In September, 1851, there was a remarkable display of the Aurora Borealis, which completely took possession of all the telegraph lines running out of the city, and effectually prevented any business being done over them during its continuance.

The following winter there was another remarkable display, which occurred upon the 19th of February, 1852. I furnish from data recorded in my journal at that time the following particulars in regard to this phenomenon.

The system of telegraphing used upon the wires during the observations of February, 1852, was Bain's electro-chemical. The circuit was what is known as the open circuit,—that is, the key, which throws the current from the battery upon the line, was always open when a message was being received from a distant station, and the current passed through the chemically prepared paper to the earth without uniting with the home battery. Each station was furnished with its own battery, the negtive pole of which was invariably connected with the earth, and the positive, by the depression of the key, with the line.

The line extended in a direction nearly northeast and southwest. The paper was prepared with a solution of cyanid of potassium, made after the following recipe. Six parts prussiate potassa dissolved in water; two parts nitric acid; two of ammonia. This solution will scarcely color the paper, while it will render it quite sensitive to the action of the electric current. The stylus was made of No. 30 iron wire. A battery of ten

* Vol. xxviii, p. 385–408.

cups Grove, with the line well insulated, will decompose the salts, and uniting with the iron stylus, leave a bright blue mark upon the paper, at a distance of 230 miles.

The positive pole only produces a colored mark; the negative bleaches the paper.

When there is no electric current upon the wires, the pen leaves no impression upon the paper; but the slightest current will produce decomposition; and the color of the mark depends upon the strength of the current.

Free or common electricity produces no color upon the paper. It emits a bright spark in passing from the stylus to the moistened paper; produces a quick, sharp noise, like the snapping of a pistol and disappears. This effect is totally unlike that of the Aurora Borealis, as will be seen from the following.

Thursday, February 19, 1852. Towards evening a blue line appeared upon the paper, which gradually grew darker and larger, until a *flame of fire* followed the pen, and burned through a dozen thicknesses of the prepared paper. The paper was set on fire by the flame, and produced considerable smoke. The current then subsided as gradually as it came on, until it entirely disappeared, and was then succeeded by a negative current, which bleached instead of colored, the paper; this also gradually increased, until, as with the positive current, it burned the paper, and then subsided, to be followed by the positive current again. This state of things continued during the entire evening, and effectually prevented any business being done over the wires. The current came in waves of varying intensity—light at first, then stronger, until having attained to the volume and intensity of at least two hundred Grove cups, it subsided, and was followed by a current of the reverse polarity. This *invariably occurred*, and may be set down as an established fact, that the currents from the Aurora Borealis always change their polarity during every wave.

I have seen the auroral current produce magnetism, decompose chemicals, and produce heat and fire.

The effects of the magnetic storm of August 28th, 1859, were apparent upon the wires during a considerable portion of Saturday evening, and during the entire day, Sunday. At 6 P. M. the line to New Bedford (60 miles in length, running a little west of south) could be worked only at intervals, although, of course, no signs of the Aurora Borealis were visible to the eye at that hour. The same was true of the wires running east through the state of Maine as well as those running north to Montreal. The wire between Boston and Fall River had no battery connected with it on Sunday, and yet there was a current upon it during the entire day, which caused the keepers of the electro-magnets to open and close as the waves came on and receded.

Upon the lines which had batteries connected Sunday evening, it was observed that the poles changed during every wave of the aurora—each wave occupying from fifteen seconds to half a minute. When the poles of the Aurora were in unison with the poles of the battery upon the line, the effect was to increase the current; but when they were opposed, to neutralize it. I will give my proofs of this farther on. It is to be observed that the effects I have illustrated in relation to the Aurora of August 28th, 1859, were observed upon the Morse (electro-magnetic) system. The same were, however, observed upon the House and Hughes lines running out of the same office.

It is not true that there is any difference in the effect produced upon the wires by the Aurora Borealis, whether they run east and west, or north and south. Lines running to every point of the compass diverge from the office here and were equally affected. Even the short wire running from the office in State street to the observatory in Cambridge (five miles long) was sensibly affected.

In an article which I published in the Boston Journal, August 31st, I stated that the current from the Aurora Borealis could have been used for telegraphic purposes, but I did not imagine it would be so soon verified by the actual fact.

On Friday, September 2d, 1859, upon commencing business at 8 o'clock A. M. it was found that all the wires running out of the office were so strongly affected by the auroral current as to prevent any business being done, except with great difficulty. At this juncture it was suggested that the batteries should be cut off, and the wires simply connected with the earth. The Boston operator accordingly asked the Portland operator to cut off his battery and try to work with the auroral current alone. The Portland operator replied, "I have done so. Will you do the same?" Boston operator answered, "I have cut my battery off and connected the line with the earth. We are working with the current from the Aurora Borealis alone. How do you receive my writing?" "Very well indeed," rejoined the Portland operator; "much better than with the batteries on. There is much less variation in the current, and the magnets work steadier. Suppose we continue to work so until the Aurora subsides?" "Agreed," said the Boston operator. "Are you ready for business?" "Yes; go ahead," was the reponse. The Boston operator then commenced sending private dispatches, which he was able to do much better than when the batteries were on, and continued to use the wire in this manner for about two hours, when, the Aurora having subsided, the batteries were resumed.

While this singular phenomenon was taking place upon the wires between Boston and Portland, the operator at South Brain-

tree—Miss Sarah B. Allen—informed me that she was working the wire between that station and Fall River—a distance of about forty miles south—with the auroral current alone. Since then I have visited Fall River and have the statement verified by the intelligent operator upon the railroad line at the dépôt in that village.

The office at the dépôt is about half a mile from the regular office in the village. The battery is kept at the latter place, but the operator at the dépôt is provided with a button or switch, by which he can throw the battery off the line, and put the wire in connection with the ground at pleasure. The battery at the other terminus of the line is at Boston, but the operator at South Braintree is furnished with a similar switch, which enables her to dispense with its use at pleasure. There are no intermediate batteries; consequently if Fall River operator puts his wire to the earth, and the South Braintree operator puts her wire to the earth, the line is without battery, and of course, without an electrical current.

Such was the state of the line upon the 2d of September last, when for nearly two hours, they held communication over the wire with the aid of the celestial batteries alone!

I have restricted myself in this article to facts observed by myself. I have stated nothing which I am not absolutely certain of, and which, if necessary, can be proved by a number of reliable witnesses.

2. *Observations made at White River Junction, Vt., communicated by* J. H. Norris, *Telegraph Superintendent.*

During the forenoon of Sept. 2d, an unusual current of varying intensity was present most of the time on the wires of the Vermont and Boston telegraph. The polarity of this current appeared to change frequently, sometimes being opposite to and nearly or quite neutralizing the battery current when an attempt was made to use the line; at other times much increasing the force of the battery current. The auroral current produced the same marks upon our chemical paper (we use the Bain or chemical system of telegraph) as those produced by the use of the battery. Signals and messages were transmitted between Boston and Manchester *by the sole use of the auroral current.*

3. *Observations made at Springfield, Mass., by* J. E. Selden.

On the evening of Aug. 28th, upon the Boston and New York circuit, at one moment there was a very heavy current on the wire, and the next none at all. On the Albany and Springfield circuit, *a flash* passed across from the break key of the telegraph apparatus to the iron frame, the flame of which was about half the size of an ordinary jet of gas. It was accompanied by

a humming sound similar to a heavy current passing between two metal points almost in contact. The heat was sufficient to cause the smell of scorched wood and paint to be plainly perceptible.

[The observations at Springfield, as well as those at New York and Washington were communicated by Messrs. Lewis and Lovett of the New York telegraph office.]

4. *Observations made at New York by* J. C. Crosson, *Telegraph operator.*

On the evening of Aug. 28th, at 7½ o'clock, I experienced considerable difficulty in working, on account of the variation of current. I could work south by constantly altering the adjustment of my magnets, but the magnetism on the eastern circuit was so nearly destroyed that I could do nothing. About ten o'clock I could see nothing of the Aurora in the southern hemisphere, yet the same variations of current were manifest upon the line for an hour afterward. There was during this time a very strong turning current from the east, which resembled a reversed current so much that I disconnected my battery and put on a 'ground,' but I could not then get magnetism sufficient to work a simple armature. At $12^h\ 30^m$ the current from the east assumed a new feature, producing enough magnetism to work quite well, yet wavering and varying in intensity.

5. *Observations made at Philadelphia, communicated by* H. Emmons Thayer, *Telegraph Superintendent.*

On the evening of Aug. 28th, about 8 o'clock, we lost current on all our four wires running from Philadelphia to New York, and we had strong circuit as if from a near ground connection; but there was no interruption on wires running south to Baltimore and Washington. At $9^h\ 10^m$ the wires were relieved to a great extent from the influence of the Aurora, giving us our usual working current.

On testing wires at 8 o'clock on the morning of Sept. 2d, I found two of our wires, those running *via* Camden and Amboy to New York, strongly under the influence of an Aurora. The effect was different from that of Aug. 28th. There was an intensity of current which *gave a severe shock* when testing, giving a reversed current, neutralizing our batteries, and destroying magnetism. On removing the batteries, we had a very strong circuit, giving powerful magnetism, but could not raise New York. On the line running from this city to Pittsburgh, the operator, Mr. Steacy, succeeded in transmitting a business message to Pittsburgh *wholly on the auroral current.* The current was changeable, suddenly disappearing and returning at intervals of from five to ten minutes. The signals were distinct and

the conversation lasted four or five minutes, the operators exchanging remarks as to the singularity of the phenomenon. At 9 A. M. all the wires were relieved from the effects of the Aurora, and worked well as usual.

6. *Observations made at Washington, D. C., by* FREDERICK W. ROYCE, *Telegraph operator.*

On the evening of Aug. 28th I had great difficulty in working the line to Richmond, Va. It seemed as if there was a storm at Richmond. I therefore abandoned that wire, and tried to work the northern wire, but met with the same difficulty. For five or ten minutes I would have no trouble, then the current would change, and become so weak that it could hardly be felt. It would then gradually change to a 'ground' so strong that I could not lift the magnet. The Aurora disappeared at a little after 10 o'clock, after which we had no difficulty. During the auroral display, I was calling Richmond, and had one hand on the iron plate. Happening to lean towards the sounder, which is against the wall, my forehead grazed a ground wire. Immediately I received *a very severe electric shock,* which stunned me for an instant. An old man who was sitting facing me, and but a few feet distant, said that he saw *a spark of fire* jump from my forehead to the sounder.

7. *Observations made at Pittsburgh, Pa., communicated by* E. W. CULGAN, *Telegraph manager.*

During the Aurora of Aug. 28th the intensity of the current evolved from it varied very much, being at times no stronger than an ordinary battery, and then suddenly changing the poles of the magnets it would sweep through them, charging them to their utmost capacity, and compelling a cessation of work while it continued.

On the morning of Sept. 2d, at my request the Philadelphia operator detached his battery, mine being already off. We then worked with each other at intervals as long as the auroral current continued, which varied from thirty to ninety seconds. During these working intervals we exchanged messages with much satisfaction, and *we worked more steadily when the batteries were off than when they were attached.*

On the night of Aug. 28th the batteries were attached, and on breaking the circuit there were seen not only sparks (that do not appear in the normal condition of a working line) but at intervals regular *streams of fire,* which, had they been permitted to last more than an instant, would certainly have fused the platinum points of the key, and *the helices became so hot* that the hand could not be kept on them. These effects could not have been produced by the batteries.

ART. XIII.—*On Numerical Relations existing between the Equivalent Numbers of Elementary Bodies;* by M. CAREY LEA, Philadelphia. Part I.

(1.)

THE determination of the chemical equivalents of the simple substances seems with each new approach to accuracy, to destroy more and more the numerical relations once supposed to exist between the equivalent numbers of certain series of elements nearly related to each other by their properties. If we except the series formed by oxygen, sulphur, selenium and tellurium, there probably remains none of those usually recognized in which the numerical relation is rigorously exact. Chlorine, bromine and iodine are represented by the numbers 35·5, 80 and 127, where the difference between the first and second term is 44·5, between the second and third, 47. Lithium, sodium and potassium have the numbers 6·95, 23, 39·2; difference of first and second terms, 16·05, of second and third, 16·20. Calcium, strontium and barium have 20, 43·77 and 68·6; difference of first and second, 23·77, of second and third, 24·83. It can be demonstrated that other relations exist, approaching quite as near to exactness as these, and some where the accuracy is perfect.

Few of the so-called elements present more directly marked analogies than nitrogen, phosphorus, arsenic and antimony, and the very interesting discoveries of Cahours and Hofmann respecting the phosphorus bases have shown that phosphorus stands in every respect intermediate between nitrogen and arsenic, forming compounds of the type $3(C_4H_5)PHCl$, &c., like the nitrogen compounds as well as those of the type $3(C_4H_5)PO_2$, &c., like those of the arsenic and antimony groups. These authors further observe that the equivalents of phosphorus, arsenic and antimony differ by nearly the same number (44 to 45), but that nitrogen does not exhibit this relation.*

Beyond the fact of the approximate equality of these two differences, the analogy has never been extended. The following considerations will show that this relation not only extends to nitrogen but may be carried with exactness to other elements.

If we form a descending arithmetical series beginning with antimony =120·3, and diminishing by a common difference of 45 (45·3 in one instance, 44 in several) we shall find that such a series does not cease with the third term, P=31, but gives for a fourth −14, the exact equivalent of nitrogen with a negative sign. The fifth term will be −59, the exact equivalent of tin, with a negative sign. The sixth will be −104, or very nearly the equivalent of lead (also with a negative sign). The seventh

* Kopp u. Will, Jahresbericht für 1857.

−149, very nearly the double of the equivalent of arsenic, a previous term in the same series. These results are exhibited in the following table.

Differences.	Calculated equivalents.	Received equivalents.
	120	Sb = 120·3
45	75	As = 75
44	31	P = 31
45	− 14	N = 14
45	− 59	Sn = 59
45	−104	Pb = 103·5
45	−149	2As = 150
45	−194	— —
45	−239	2Sb = 240·6
45	−284	— —
44	−328	= 2×164
44	−372	— —
44	−416	2Bi = 416

It will be seen presently that the number 164, the eleventh term in the above table, occurs also in the ascending positive series, and may represent the equivalent of a metal existing but as yet unknown.

If we examine the position occupied by antimony, arsenic, phosphorus and nitrogen in the electro-chemical scale of Berzelius we shall find that in proportion as their equivalent numbers diminish, their properties become more and more electro-negative; a corresponding change is also visible in the organic radicals which these elements are capable of forming by their union with carbon and hydrogen. The passage from the positive to the negative sign in the interval between phosphorus and nitrogen is accompanied by a marked change in the nature of the organic radicals into which these elements enter—$3(C_4H_5)N$ does not possess the power of combining directly with oxygen, chlorine and sulphur which $3(C_4H_5)P$, $3(C_4H_5)As$, $3(C_4H_5)Sb$ exhibit in so high a degree. The methyl compounds show the same differences as the ethyl. Standing between nitrogen and arsenic, phosphorus is every way more closely allied to the latter or

these substances, not only by the analogies of its organic radicals, but also by the polybasic nature of phosphoric acid.* Although tin and lead represent the further members of the same series in reference to their equivalent numbers, it is evident that the increase of electro-negative relations does not extend to them. Moreover bismuth, antimony, arsenic, phosphorus and nitrogen at their maximum of oxydation combine with five equivalents of oxygen and chlorine, whereas tin unites with but two of each, and lead at most with two of oxygen and one of chlorine.

Again, if we begin with phosphorus, and form an ascending series with a common difference of 44 (except in one instance), we shall find both the number 164, the double of which constituted the eleventh term of the preceding table, and also the equivalent of bismuth, the double of which formed the thirteenth term of the same table.

Differences.	Calculated equivalents.	Received equivalents.
	31	P = 31
44		
	75	As = 75
45		
	120	Sb = 120·3
44		
	164	— ——
44		
	208	Bi = 208

These four elements exhibit strong analogies and are all isomorphous with each other.

If, taking mercury as a starting point, we subtract the number 44 from each term to find the following one, we shall obtain the series—

Differences.	Calculated equivalents.	Received equivalents.
	100	Hg = 100
44		
	56	Cd = 56
44		
	12	Mg = 12
44		
	−32	Zn = 32·6

The salts of the protoxyds of the three last of these metals are isomorphous. It may seem forced to place mercury in the same group, but its analogies with zinc are perhaps as strong as those which it exhibits with silver, next to which it has usually been classed, principally because the oxyds of both metals are reduced by heat. Mercury, like zinc, cadmium and certain other metals, is capable of replacing an atom of hydrogen in hydrid of ethyl, C_4H_5H, and of producing in this manner the conjugate

* See the very interesting paper of Cahours and Hofmann above referred to.

organic radical mercur-ethyl, C_4H_5Hg, analogous to zinc-ethyl, C_4H_5Zn. This compound has recently been isolated by Buckton.* Silver does not appear to be capable of a similar substitution; when chlorid of ethyl is made to react upon zinc-ethyl the products are ethyl, chlorid of zinc and metallic silver. It has lately been shown by Hallwachs and Schafarik that magnesium forms an ethyl-magnesium.† These metals are likewise all volatile, and it has been shown by H. St.C. Deville that magnesium, like the others, is readily distilled.

It is not a little curious that the numerically negative members of this series lead into the positive members of the foregoing; if we continue the subtraction of 44, we find for the fifth number 76, or nearly the equivalent for arsenic, for the sixth 120, very nearly that of antimony, for the seventh 164, corresponding, as before remarked, with a possible undiscovered metal, and for the eighth 208, or exactly the equivalent of bismuth. The two series thus naturally lead to each other. The equivalent for arsenic given by L. Gmelin, viz. 75·4, accords more nearly with some of these series and renders them more exact than that adopted by the Jahresbericht which has been here employed.

The members of these two analogous series are further united by the fact that all of them, eleven in number, are capable of uniting with the hydro-carbons of the methyl, ethyl, &c. type to form powerful organic metals, and that this capacity appears to be limited to these elements alone.‡

(2.)

The magnesia group includes a well marked natural family of metals, whose oxyds having the constitution RO are related with each other by isomorphism. The equivalents of these metals, according to the most recent determinations, are as follows:

Magnesium,	12	Chromium,	26·7
Manganese,	27·5	Zinc,	32·6
Iron,	28	Cadmium,	56·
Cobalt,	29·5	Copper,	31·7
Nickel,	29·6	Lead,	103·5
Uranium,	60		

[Some of the elements here enumerated are found also in the foregoing or following series. It need scarcely be remarked that no absolute classification into groups is possible; lead for instance is in some of its combinations isomorphous with the barium group, in others with the magnesia, copper in grey cop-

* See this Journal, [2], xxviii, 146. † This Journal, [2], xxviii, 147.

‡ There appears some reason to believe that an ethyl-aluminum may exist, which would form an exception to this law. If so, the same property may possibly be extended to others of the metals of the earths.

per ore is isomorphous with silver, while its carbonate, sulphate and seleniate are isomorphous with those of the magnesia group.] The equivalents of the above metals are related in the following manner by the number 44:

Cu 31·7	Zn 32·6	Cd 56
Mg 12·	Mg 12	−Mg 12
43·7	44·6	44
U 60	U 60	U 60
Mn 27·5	Fe 28	Co 29·5
87·5, ½=43·75	88, ½=44	89·5, ½=44·75
U 60	U 60	Pb 103·5
Ni 29·6	Cr 26·7	−U 60
89·6, ½=43·5	86·7, ½=43·35	43·5
Cd 56	Cd 56	Pb 103·5
Zn 32·6	Cu 31·7	Fe 28
88·6, ½=44·3	87·7, ½=43·9	131·5, ⅛=43·8

and so likewise by adding to the equivalent of lead, the equivalents of manganese, cobalt, nickel, and chromium, we obtain in each case a number almost exactly equal to three times the number 44.

To sum up: with Cu and Mg, Zn and Mg the sum of each pair is 44 nearly.

With Cd and Mg, Pb and Ur, the difference of each pair is 44 or nearly.

With U and Mg, U and Fe, U and Co, U and Ni, U and Cr, Cd and Zn, the mean term is 44 or nearly.

With Pb and Mn, Pb and Fe, Pb and Ni, Pb and Co, Pb and Cr, the sum of each pair is three times 44 nearly.

It has been before pointed out that the strong analogy existing between Mg, Cd and Zn extends to their equivalents, that of Mg being added to that of Zn gives the number 44 nearly, subtracted from that of Cd, 44 exactly.

(3.)

The following metals may be classed together as tending to form acids:

Tin, 59	Vanadium, 68·8
Titanium, 25	Molybdenum, 48
Tantalum, 68·6	Tellurium, 64
Tungsten, 92	Niobium, 48·82*

Relations depending upon the number 44 exist between these equivalents.

* By the recent determination of H. Rose, Poggendorff, civ, ext. in this Journal, [2], xxvii, 127.

If from Ta 68·6 we subtract Ti 25, the remainder is 43·6, 44 nearly.

If from V 68·8 we subtract Ti 25 the remainder is 43·8, 44 nearly.

If from W 92 we subtract Mo 48 the remainder is 44 exactly.

If from W 92 we subtract Nb 48·82 the remainder is 43·18.

If to Te 64 we add Ti 25 the sum 89 is twice 44 nearly.

If to Te 64 we add Ta 68 the sum 132·6 is three times 44 very nearly.

If to Te 64 we add V 68·8 the sum 132·8 is three times 44 very nearly.

If the equivalent of Sn=59 be multiplied by $\frac{3}{4}$ the result is 44·25, in other words $3Sn=4\times44{\cdot}25$.

If we add Sn 59, Ta 68·6, W 92, V 68·8 and Te 64, the result is 352·4, $8\times44=352$.

If we add Ta 68·6, Nb 48·82, Sn 59, we have 176·42, $4\times44=176$.

If we add Ta 68·6, Mo 48, Sn 59, we have 175·6, $44\times4=176$.

If we add W 92, 2Te 128, we have 220, $5\times44=220$.

If we add Ta 68·6, Mo 48, 2Sn 118, V 68·8, Nb 48·82, we have 352·22, $8\times44=352$.

These analogies, though many are very complex, approach exceedingly near to absolute exactness; in the last for instance the difference amounts to only $\frac{1}{1\,8\,0\,7}$ of the whole amount.

(4.)

If commencing with gold, Au=197, we form a diminishing series with a common difference of 44·5, we shall find for its terms—

Differences.	Calculated equivalents.		Received equivalents.
	197		Au=197
44·5	152·5	—	——
44·5	108		Ag=108
44·5	63·5		Cu = 63·4

The equivalent of Cu has been here taken at double that usually employed, or that which results from taking the first oxyd of copper as CuO, a view formerly entertained by Berzelius, L. Gmelin and other distinguished chemists.* It is doubtful if this be not the true equivalent; in grey copper ore, if we consider Cu as 32·7 we must admit that one equivalent of silver is replaced by two of copper, which is improbable. Moreover the two sulphides, AgS and CuS (Cu=63·4) are isomorphous.†

* Thomson, Inorganic Ch., i, 592.

† L. Gmelin, Handbook, i, 95. The recent experiments of Cannizaro give additional reason for doubling the equivalent of copper.

Viewed in this light the above series approaches very near to exactness, and may probably be wholly so, for the equivalent of copper is by no means positively known. Dumas' recent researches were too unconcordant to permit him to offer a positive opinion. It will be shown further on that these metals, as well as many others here grouped together by relations depending upon a number approximating to 44·5, are also united by analogies of atomic volume.

The second number in the above series, 152·5, does not correspond with the equivalent of any known element, and it, like the number 164, which occurs twice in the nitrogen series, may represent the equivalent of some elementary body as yet unknown. In the second part of this paper, an additional argument will be presented in favor of the possible existence of two elements having these equivalent numbers.

The same relation may be extended with more or less approximation to the platinum group, which naturally subdivides itself into two families: the members of each family have very nearly the same equivalents, and the difference between the equivalents of the two families approaches to 45.

Rhodium,	52·2	Platinum,	98·7
Ruthenium,	52·2	Iridium,	99
Palladium,	53·3	Osmium,	99·6

The difference between the equivalents of platinum and palladium is 45·4, the rest vary a little more.

The elements, carbon, boron and silicium, are united by the number 44 in the following manner: if we take Gerhardt's equivalent for carbon $\epsilon=12$, the sum of the equivalents of these three substances amounts to 44 exactly.

Carbon (ϵ),	12
Boron,	11*
Silicium,	21·
	44

With respect to the metals of the earths and alkaline earths, magnesium and calcium have been considered elsewhere, yttrium, erbium and terbium, and the cerite metals have not yet been sufficiently examined, the equivalents of the three first have in fact not yet been determined, thorium exhibits a relation which will be hereafter pointed out; there remain therefore glucinum, aluminium and zirconium. The equivalents of these metals, viz. 4·7, 13·7 and 22·4 are evidently too small to follow precisely the same law which governs the various series previously considered, but that it extends also to them becomes evident

* As determined by Deville by analyses of bromid of boron.

by multiplying their equivalents by 5, when they form a series analogous to the foregoing.

Differences.		
45	23·5 - -	5G = 23·5
45	68·5 - -	5Al= 68·5
	113·5 - -	5Zr =112·

(5.)

If we take the equivalent of nitrogen, add to it three times 45 and divide by 8, we shall have nearly the equivalent of fluorine, and by continuing nearly in the same manner, we obtain those of chlorine, bromine and iodine.

$$\frac{14+3\times45}{8} = 18{\cdot}62, \quad Fl = 19$$

$$\frac{14+6\times45}{8} = 35{\cdot}5, \quad Cl = 35{\cdot}5$$

$$\frac{14+14\times45}{8} = 80{\cdot}5, \quad Br = 80$$

$$\frac{2\times14+22\times45}{8} = 127{\cdot}25, \quad I = 127$$

(6.)

Several elements, taken in pairs, have equivalents which differ from each other by a number approximating to 45.

Na	23	+ 45·6 =	Ba	68·6
Be	4·7	+ 43·3 =	Di	48
Ti	25	+ 43·6 =	V	68·6
Cl	35·5	+ 44·5 =	Br	80
Al	13·7	+ 45·9 =	Th	59·6
Zr	22·4	+ 46·4 =	Ba	68·6

(7.)

At the commencement of this paper reference was made to the well known numerical relations existing between Li, Na, K; Ca, Sr, Ba; Cl, Br, I. Inexact as are these (with the exception of the first which approaches tolerably near), the strong analogies which exist between the substances themselves, give to their relations an interest which they would not otherwise possess, and it is to be remarked that they all belong to that class which it has been the object of this paper to develop, viz., those depending upon the number 44–45.

1. The equivalent of sodium is well known to be nearly a mean between those of lithium or potassium—if the equivalent

of lithium be added to that of potassium, or if that of sodium be doubled, a number is obtained in either case approaching nearly to 45.

2. The equivalent of strontium is nearly a mean between those of calcium and barium: Sr=43·75, half the sum of Ba 68·6 and Ca 20 is 44·3; in either case 44 nearly.

3. The equivalent of chlorine, 35·5, subtracted from that of bromine, 80, gives 44·5. The equivalent of bromine subtracted from that of iodine gives 47.

(8.)

With respect to three of the groups already considered, a further relation exists. For greater clearness the groups in question have been arranged in the following table:

Group A.			Group B.		
Differences.			Differences.		
	100	Hg=100		208	Bi =208
44	56	Cd= 56	44	164	— —
44	12	Mg= 12	44	120	Sb =120·3
44	−32	Zn = 32·6	45	75	As = 75
			44	31	P = 31
Group C.			45	−14	N = 14
	92	W = 92	45	−59	Sn = 59
44	48	Mo= 48	44·5	−103·5	Pb =103·5

If to the equivalent of the substances forming series A, we add successively to each term the equivalent of fluorine, we shall obtain four corresponding terms of series B.

Mercury	100	Cadmium	56	Magnesium	12	Zinc	−32·6
Fluorine	19	Fluorine	19	Fluorine	19	Fluorine	19
	119		75		31		−13·6
Antimony	120·3	Arsenic	75	Phosphorus	31	Nitrogen	14

Further: If to two corresponding terms of series A we add the equivalent of chlorine, we shall obtain the two terms of series C.

Cadmium	56	Magnesium	12
Chlorine	35·5	Chlorine	35·5
	91·5		47·5
Tungsten	92	Molybdenum	48

And if to two terms of the same series A we add the equivalent of bromine, we also find the terms of series C.

Magnesium	12	– Zinc	– 32·6
Bromine	80	Bromine	80
	92		47·4
Tungsten	92	Molybdenum	48

If we add respectively the four terms of series A with the four corresponding terms of series C, we shall in each case obtain a number which is very nearly twice forty-four; that is, the mean of each pair of series is 44 nearly.

– Zinc	– 32·6	Magnesia	12	Cadmium	56	Mercury	100
Antimony	120·3	Arsenic	75	Phosphorus	31	– Nitrogen	– 14
	88·7		87		87		86

It will be remarked that where a series leads to the equivalent of an element, but with a negative sign, that negative sign has been in all cases preserved in the further examination of its numerical relations.

(9.)

It is evident that the number 44—45 plays an important part in the science of stoichiometry, and the relations which depend upon it are supported, in some cases at least, in a remarkable manner, by analogies of atomic volume. That such analogies are a support becomes evident from the following considerations.

Solids and liquids are very far from being governed by the laws which determine the combinations of gases, in volumes either equal or having some very simple relation to one another. Therefore, if we find that in some few instances such a relation does hold good with solid substances, we may naturally expect to find a close relationship existing between those substances thus united. We may even be permitted, by way of hypothesis, to advance a step further, and finding that a given volume of silver unites with a given volume of oxygen, and that the same volume of gold unites with precisely the same volume of oxygen, to conjecture that gold may differ from silver only by a third substance, which unites with the silver without increasing its volume, or affecting the amount of oxygen which it is capable of saturating, but which, on the other hand, alters its chemical equivalent, its specific gravity, and other physical characters.

Moreover, if we find that by subtracting from the chemical equivalent of silver, half the difference between the equivalents of silver and gold, we obtain the equivalent of a third metal, copper ($Eu = 63·4$), which also, under equal volumes, combines with a quantity of oxygen expressed by a very simple relation

with that capable of saturating gold and silver, we may at least speculate that the three may form a series consisting of two substances combined in different proportions. It is true that we must be extremely cautious about venturing upon hypotheses involving a compound constitution of bodies which all our efforts have hitherto proved ineffectual to decompose, but on the other hand it must be admitted that when we find so-called elements arranging themselves into a series of terms having a common difference, and when we find the terms of these series united by equality or simple relation of atomic volume, we cannot grant that their elementary nature has been absolutely established.

The following substances combine relations of chemical equivalents already pointed out, with analogies of atomic volume:

Differences of Equivalents.		Atomic† volume.	Relation of At. vol.
45*	Nitrogen, - - -	14·42	- 2
44	Phosphorus (vapor), -	7·01	- 1
	Arsenic (vapor), - -	7·07	- 1
44·5*	Lead, - - -	9·09	- 1
	Tin, - - -	8·09	- 1
45*	Nitrogen,		
45	Phosphorus, - -	17·7	- 2
44	Arsenic, - - -	12·58	- $\frac{3}{2}$
45·3	Antimony, - -	18·—	- 2
87·7 or twice 43·85	Bismuth, - - -	21·18	- $\frac{1}{3}$

(Where phosphorus, arsenic, &c., are compared in the solid state, the unit of relation is of course different). It has been already remarked that in point of chemical relations generally, lead and tin are less closely united with the series than the other members composing it, but the relation between the atomic volumes of lead and antimony, the latter almost the last term at the other end of the series, is almost absolutely exact. Nitrogen is of course omitted in the second table, as we do not know what would be its atomic volume in the solid state.

* In the cases of nitrogen, tin and lead, the equivalents are taken with a negative sign, as before explained.

† The numbers here given for the atomic volumes are calculated from the specific gravities adopted in Gmelin's Handbook, and the latest and most reliable determinations of chemical equivalents.

Differences.		Atomic Volume.	Relation of At. Vol.
89 or twice 44·5	Gold, - - -	10·26	- - 1
	Silver, - - -	10·35	- - 1
44·6	Copper (Cu=63·4), -	7·27	- - $\frac{3}{4}$

It will be observed that the difference between the equivalents of copper and silver approaches very near to absolute exactness with half the difference between the equivalents of silver and gold, and as the equivalent of copper is by no means positively settled, the relation may be rigorously exact. If we take the mean between the number adopted by L. Gmelin and that adopted by the Jahresbericht (always considering cuprous oxyd as CuO), we shall have for the difference between the equivalents of copper and silver the number 44·5, half the difference between the equivalents of silver and gold, with mathematical exactness.

Difference.		Atomic volume.	Relation of At. vol.
44	Tungsten, - -	5·28	- - 1
	Molybdenum, -	5·58	- - 1

In the series Hg, Cd, Mg, Zn, similar analogies are not well marked: the atomic volumes of the three first metals are not very far apart,

	Atomic volume.
Hg, - - - -	7·37
Mg,* - - -	6·85
Cd, - - - -	6·48

but the atomic volume of zinc differs considerably; it is 4·72.

In each of these different series, each term differs in its equivalent by the number 45 or a number approaching very near to 45, and yet the addition of this large amount of matter is in most cases accompanied by no change in volume, or when a change takes place, it is expressed by some simple relation to the original volume. Some of these relations of atomic volume are well known and are only here presented in view of the confirmation which they afford of the series here established, but it is believed that the connection of the atomic volume of copper with those of gold and silver, and of those of tin and lead with those of the elements of the antimony group are pointed out for the first time.

Ammermüller has noticed a fact not wholly dissimilar from this in the case of protoxyds of copper, mercury, tin and lead, which combine with a second equivalent of oxygen without change of atomic volume, the density alone increasing. But according to L. Gmelin, the specific gravities on which he based

* Taking the sp. gr. of magnesium at 1·75 as determined by Deville.

his calculations are too unreliable to render the fact well established.

The numbers adopted for the equivalents in the foregoing calculations are those obtained by the latest and most reliable determinations; they are taken from the table contained in the Jahresbericht der Chemie of Kopp & Will for 1857, published in August, 1858, and the last which the author has been able to obtain at the time of concluding this paper, and have been in no case altered or modified in the slightest degree with a view to preserve or increase numerical relations, which by slight changes of this kind can be often rendered much more symmetrical. Dumas, in one of his highly interesting papers on this subject* (Comptes Rendus, XLV, 709, extracted in Kopp and Will's Jahr. 1857) in his series $a+xd+yd'$, adopts the equivalents N=14, P=31, As=75, Sb=119, Bi 207 (see Jahresbericht, p. 35, where the equivalent of Bi is erroneously printed 108, by substitution of the values given for a, x, y, d, and d', 207 is obtained): whereas the equivalent of Sb as lately found by R. Schneider, confirmed by H. Rose, and adopted by Kopp & Will is 120·3. In another place (Comptes Rendus, XLVII, 1027) Dumas has taken the equivalent of the same metal at 122, thus adopting alternately the numbers 119 and 122, neither the true one, according to the exigencies of the two series. The equivalent number of bismuth in the series just mentioned is taken at 207, whereas it should be 208. In the series $a+xd$ we find Mg=12, Ca=20, Sr=44, Ba 68, Pb 104—the last three should be Sr 43·77, Ba 68·6, Pb 103·5. So with Li, Na, K, V, Zr, &c.

In the foregoing tables the calculated and received equivalents are placed by side of each other for comparison. The differences rarely exceed the possible errors in the determination of chemical equivalents, respecting some of which there is still much doubt. Dumas, in the paper above referred to, gives the results of many new determinations by himself, and arrives at the number 26 for both chrome and manganese, instead of the ordinarily received Cr=26·7, Mn=27·5. For copper his results disagreed too much to lead him to any positive conclusion.

The analogies here presented, all depending upon the same or approximately the same number, extend therefore—

To the series Pb, Sn, N, P, As, Sb, Bi.
To the series Hg, Cd, Mg, Zn.
To the series Au, Ag, Cu.
To the magnesia group, including Mn, Fe, Co, Ni, U, Co, and some of the metals also classed in the three preceding series.

* The interesting paper of Prof. Cooke (Memoirs Amer. Ac., 2d ser., vol. v) to which the author's attention has been called since concluding this paper, will be more particularly referred to in the Second Part.

To the metals belonging to the group Ti, Ta, W, V, Mo, Te and No; Sn belongs also to this series as well as to the first.
To the platinum group, Rh, Ru, Pd, Pt, Ir, Os.
To C, B, Si.
To G, Al, Zr.
The differences between Cl and Br, Br and I, approximate to the same number, as likewise do the relations between Li, Na and K, and between Ca, Sr and Ba.

This relation, therefore, extends to no less than forty-eight of the elementary bodies: to all except those as yet imperfectly understood, most of which may yet range themselves under the same law, and except the oxygen group, oxygen, sulphur, selenium and tellurium, substances which stand alone and unmistakably apart from the other elements.

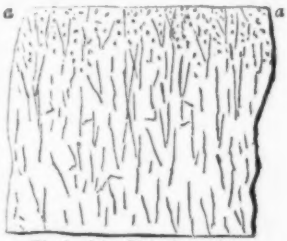
Philadelphia, Nov. 10, 1859.

ART. XIV.—*Remarks on the Dissolution of Field Ice;* by CHAS. WHITTLESEY, of Cleveland, Ohio.

THE interesting paper of Col. Totten, U. S. A., in the November number of this Journal for 1859, upon the rapid disappearance of ice in the northern lakes, recalls some observations that I had an opportunity to make on Lake Superior a few years since.

On the 8th of March, 1855, the inhabitants of Eagle River, a village in Haughton County, situated upon the most northerly part of Point Kewenaw, were engaged in procuring ice for their summer use. The severity of winter in that latitude (47° 22′ north) had so far relaxed, that the surface of the field was slightly porous from the direct action of the sun. There had been no rain; the atmosphere was clear and cool, but on the sunny side of houses and other objects the snow melted rapidly in the day time.

Below the soft and moist surface, at a few inches in depth, the ice was solid and pure to the bottom, its thickness being thirty inches. The blocks which the people were cutting out, were taken about 1000 feet from the shore. One of them nearly in the form of a cube, of thirty inches on each face, was suffered to lie upon the unbroken ice, its natural surface uppermost, as represented in the figure here inserted.



Block of ice 30 inches thick.
a a, upper surface.

I was thus enabled to take a direct view of the progress of its decay, as no doubt others have done many times, upon these lakes. As the force of the sun increased, the porous part on the

surface increased rapidly in depth, lines or planes of separation extending downward from it into the hitherto transparent and homogeneous mass. There were not at any time horizontal planes visible, indicating layers or lamination, in the original structure. A thin film of matter followed each newly formed crevice downwards, and bubbles of air rose continually through the same to the surface. These planes of division converged below, giving the block the appearance above represented, of inverted spikes or rudely formed pyramids, with their bases upward.

By ten o'clock A. M. the upper half of the block was divided in this manner. The figures were somewhat regular and were principally triangular and rectangular, reminding me of the imperfectly columnar red trap of the north shore of Lake Superior. By noon the block was so far disintegrated that it fell to pieces under a single blow, and remained a pile of roughly formed spikes, pyramids and prisms of various lengths. After this as so much new surface was exposed to the sun it melted very fast. The newly cut ice was still solid and clear except a few inches at the surface.

There seemed to be in the block that had so suddenly lost its form and solidity, a process of contraction, arising from an increase of temperature. I presume that this appearance can be thus accounted for. No doubt the planes of division existed in the solid ice, as results of the crystallization in freezing. The general law of structure in all masses slowly crystallizing from a state of fusion is the production of a prismatic structure perpendicular to the cooling surfaces. Basalt assumes its polygonal figures in obedience to the same law, and the structure of ice is quite in accordance with it. Its effects are not wanting even in some pastes, like starch and domestic cake.

This structure exists often where it is concealed. An ingot of block tin shows no crystalline structure, but by slow fusion the amorphous parts melt and run out leaving a skeleton of crystalline prisms. Ice is in the same predicament, and since in freezing water expands one-seventh of its volume, the first result of the fusion of a part of it is to dissect out the prismatic masses, leaving them standing isolated by reason of their being on a larger scale than the fluid volume from which they were formed. In this process the air bubbles no doubt materially assist by opening channels of escape for the ice-water.

What I have stated may assist in explaining why immense fields of fresh water ice disappear in a single gale of a few hours duration. When the temperature rises above 32° the ice soon loses its cohesion, and the first agitation breaks it up. In popular phrase it sinks, and is thus lost sight of suddenly; but in truth it is dissolved by the warmer water acting upon the fragments in the shape of little columns and pyramids such as Col. Totten saw strewed along the shore of Lake Champlain.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On Platinum and the metals which accompany it.*—H. St. Claire Deville and Debray have published a very interesting and valuable memoir on the platinum metals, considering the subject rather from a metallurgical than from a purely chemical point of view. For the details of the processes employed we must refer to the original memoir, which rarely admits of abridgment, and which is in the highest degree instructive. The authors employ exclusively the *dry* method of investigation and operate at temperatures much higher than any which have hitherto been obtained upon a working scale. By a new arrangement of the oxy-hydrogen blowpipe most of the members of the platinum group may be fused—platinum even in larger quantities than was accomplished by Dr. Hare. By the same apparatus properly employed, the authors purify the metals and their alloys from more volatile elements with which they may be mixed. Osmium has a density of 21·3 to 21·4, and when dissolved in tin exhibits traces of a crystalline structure. It is bluish white, has no odor, and gives off vapors of osmic acid only above the temperature of melting zinc. At the temperature of melting ruthenium, osmium is sensibly volatilized but it does not fuse, and hence resembles arsenic in having its boiling point lower than its point of fusion. Two determinations of the density of the vapor of osmic acid gave 8·88 and 8·89, corresponding to 2 vols. Next to osmium ruthenium is most difficult of fusion, but may yet be obtained in small fused masses when its density is from 11 to 11·4. The authors give analyses of the protoxyd of ruthenium and of the crystallized deutoxyd isomorphous with stannic acid. They also describe a beautiful alloy of ruthenium and tin having the formula $RuSn_2$ and crystallizing in cubes. Palladium fuses even more readily than platinum, and volatilizes at the temperature at which iridium melts. It also absorbs oxygen when fused like silver without becoming oxydized. Its density at 22·5° is 11·4. With tin it forms an alloy crystallizing in small brilliant plates having the formula Sn_2Pd_3. Rhodium fuses less easily than platinum; it has about the color of aluminum and when pure is malleable and ductile; its density is 12·1. It forms crystalline alloys with zinc and tin.

Platinum may (as first shown by Dr. Hare) be fused in large quantities before the oxy-hydrogen blowpipe. Deville and Debray give a detailed description of the apparatus by which this metal may be fused in quantities of not less than 12 to 15 kilograms at an expense of from 0·24 fr. to 0·40 fr. per kilogram. (The late Dr. Hare fused 28 ounces at one operation.) The fusion of platinum is best accomplished in crucibles of lime, which serve to refine the metal by absorbing the impurities. When fused and refined, platinum is as soft as copper; it is whiter than ordinary platinum and free from porosity; its density is 21·15. With tin platinum forms a beautiful crystallized alloy having the formula Pt_2Sn_3. Iridium requires an extremely high temperature for its fusion, but when fused has a pure white color, and is brittle under the hammer like a crystalline metal; its density is the same as that of platinum, namely 21·15.

(Dr. Hare, who long ago succeeded in fusing iridium, found its density 21·83.) Iridium forms with tin a beautiful alloy crystallizing in cubes having the formula $IrSn_2$.

The authors remark that the alloys of platinum with iridium and rhodium are much more valuable in the arts than pure platinum, many of them resisting the action of aqua-regia, and possessing a considerable degree of hardness and rigidity. The memoir contains in addition numerous elaborate analyses of different specimens of platinum ore and of osmiridium, as well as new processes for the treatment of platinum ores upon the larger scale, the preparation of pure platinum for industrial purposes, and of alloys of platinum with its associate metals possessing useful properties. For these we must refer to the original.—*Ann. de Chimie et de Physique*, lvi, 385, Aug. 1857.

[*Note.*—A memoir read before the Am. Association for the Advancement of Science at its meeting in August 1859, and shortly to appear in the 12th volume of the Transactions of the Smithsonian Institution, contains entirely new processes for the separation of all the platinum metals in a state of absolute purity. These processes are in the wet way; they are very simple and easy of execution, and they not only apply to the separation but to the qualitative analysis of mixtures of the different metals of this group in almost any proportions. The methods in question involve the preparation and properties of a new and remarkable series of salts, and will I hope be found to remove completely the difficulties which have hitherto surrounded the subject.—W. G.]

2. *Blowpipe experiments.*—Bunsen has contributed some very interesting additions to our knowledge of the use of the blowpipe in quantitative as well as qualitative analysis. The author employs the peculiar form of gas burner, first introduced by him, and now used in all laboratories, instead of the blowpipe. The lower part of the flame is surrounded by a conical sheet iron chimney, 30^{mm}. in diameter above, and 55^{mm}. below, so that the burner tube is in the axis of the chimney and 45^{mm}. below the upper base of the cone. The cock is to be regulated so that the apex of the inner non-luminous cone of gas within the flame exactly reaches the level of the upper base of the chimney. In this manner we obtain a flame of perfectly constant dimensions which is immovable, sharply defined in all its parts, and which may always be obtained of uniform character. The outer cone of flame has a very faint sky-blue color, which is invisible even by feeble daylight. The inner cone of flame is less intensely blue than the outer. The object to be submitted to the action of the flame must never be larger than the half or the third of a grain of millet seed. It is to be introduced into the flame by means of a little loop on the end of a platinum wire which is attached to a holder by which it may be moved gently and steadily, so that the object may be introduced into any part of the flame. The loop is to be moistened with water, when a grain or a little of the powdered substance will readily adhere to it.

The author remarks that the temperature which the flame is capable of producing depends principally upon the constitution of the gas consumed. The temperatures corresponding to gas analyzed in the Heidelberg laboratory on four different occasions were 2369 C., 2352 C., 2391

C., 2386 C., or as a mean, 2350 C., so that the temperature of the flame where the quantity of air is exactly sufficient for the combustion of the gas, may be assumed in round numbers as 2300 C. It is easy to see, however, that the temperature will vary in different parts of the flame. The author gives a simple and elegant method of determining the point of maximum temperature by introducing a platinum wire into the flame, and determining at what point the light emitted by this is most intense. In this manner it is found that the zone of maximum temperature lies in the external cone of flame, a few millimetres above and below the apex of the internal non-luminous cone, which is on a level with the upper base of the chimney. The author employs this zone to investigate the action of a temperature of 2300 C. upon different substances, and terms it the *melting space*. The outer border of this *melting space* acts as an oxydizing flame, the inner as a reducing flame, the reduction being most powerful immediately above the apex of the innermost cone. The great constancy which the flame exhibits in all its parts allows us to observe and estimate the volatility of substances at the very high temperature of 2300 C. For this purpose a mass of matter having a measured diameter of 1 millimeter is introduced into the flame, and the time required for complete evaporation determined by means of a seconds pendulum or a metronome. The size of the mass introduced upon the platinum wire is easily regulated by adding new substance or by evaporation in the flame, and may be measured under the microscope. The author takes the volatility of carbonate of soda as unity, and gives a table of the comparative volatility of different substances in terms of this unit: thus the volatility of chlorid of potassium is 15·33; of chlorid of sodium 6·57; of phosphoric acid 23·00. Other substances are more or less completely decomposed at the temperature of 2300 C.

Besides its use in experiments on volatility the flame may also be employed for a series of other very valuable blowpipe reactions, among which the author cites the quantitative determination of soda in the presence of potash and lithia.

For the simple recognition of soda in its volatile salts, it is sufficient to introduce a small bead of the substance into the melting space and then to illuminate a crystal of bicromate of potash with the light produced. The salt appears perfectly colorless, transparent, and with a diamond lustre so long as the rays of the soda flame fall upon it, and this even by ordinary lamplight or daylight. A still more delicate reaction is obtained by using paper, covered with iodid of mercury, a square centimeter of which may be attached to the chimney in front of the flame by a movable arm. If we introduce the smallest quantity of a soda compound into the melting space, the red paper appears white, with a faint tinge of tawny yellow. When the soda salt is in solution the loop of the fine platinum wire may be flattened under the hammer to a little ring. This ring introduced into the liquid will take up a drop which must be gently evaporated to dryness and then tested as before. In this manner $\frac{4}{10,000}$ of a milligram of common salt may be easily detected.

Volatile potash compounds, as is well known, communicate a bluish violet tint which is completely concealed by small quantities of soda. In this case the potash may easily be detected by means of Cartmell's

reaction, that is, by looking at the flame through a deep blue cobalt glass, when a violet or ponceau-red color appears. This potash test is even more delicate than that for soda, $\frac{2}{10.000}$ parts of chlorid of potassium may be detected with perfect distinctness.

The detection of lithia in the presence of potash and soda is best effected by looking at the flame through a hollow prism filled with a solution of sulphate of indigo. The carmine-red color of the lithia flame disappears when a certain thickness of solution is reached, and if a mark be put upon the prism, all the layers of liquid above the mark will allow only the red potash-rays to pass through. Lime and soda have no influence on this reaction. When potash and lithia are both present the flame from the salt to be tested should be compared with that of pure potash. The flame containing lithia and potash appears through thin layers of liquid redder than the potash flame alone; through thicker layers the potash flame appears scarcely weakened. In this manner some thousandths of lithia may the discovered in potash salts.

To render these processes available for silicates Bunsen mixes the mineral with pure gypsum and heats in the melting space, when silicate of lime and volatile sulphate of potash are formed. By comparing the intensity of the color produced by a mineral to be tested with that of a series of silicates whose percentages of alkali are known, it is easy even with very small fragments to determine the relative quantities of potash, soda and lithia with tolerable approximation.

The author in the first place determines whether the mineral to be examined contains lithia or not by the method already explained. The minerals of the first group are those containing no lithia, and the author arranges a scale of minerals for comparison according to the content of soda in each. These are—

	NaO	KO
1. Lazulite,	9·09	—
2. Nepheline,	15·44	4·94
3. Albite,	10·06	—
4. Orthoclase,	7·08	7·03
5. Sanidin,	4·0	8·0
6. Labradorite,	2·55	1·06
7. Anorthite,	1·13	0·62
8. Leucite,	—	2·2

These are to be ignited, pulverized and preserved with their numbers as blowpipe reagents. One of these and the mineral to be tested, with or without gypsum, are to be introduced into the flame together so that small equal ends of wire are ignited; the iodid of mercury paper then appears more or less bleached. Remove the test from the flame, if now the paper shows a reddish tint, the test contains more soda than the mineral used for comparison. If the paper however becomes paler the contrary is the case. In this manner it is easy to determine between what two minerals the test lies, so that the percentage of soda may be estimated within a few per cent. The substances to be compared must be as nearly as possible in equal quantities, the ignited lengths of wire be the same and the soda-flame of the same size and form. The eye must be accustomed to distinguish the different degrees of brightness of the same tint

from actual differences of tint. When the iodid paper is intensely bleached it may also be illuminated by a candle flame so that the soda-flame produces with this foreign light a white tint nearer to red.

The potash color-test is not as accurate quantitatively as that for soda. It is sufficient for all purposes to distinguish *a slight*, *a strong*, and a *very strong* potash reaction, using for comparison in succession the flame of oligoclase, orthoclase and leucite heated with gypsum in the same flame with the test. The indigo prism is to be used and the dimensions, color and duration of the red flames observed.

Lazulite gives a stronger soda reaction than nepheline because it contains sulphuric acid, and it is always necessary to determine beforehand whether the test contains sulphuric acid, chlorine or fluorine. This is best accomplished by the common blowpipe.

For further details we must refer to the original memoir, which must create an entirely new department in blowpipe analysis.—*Ann. der Chemie und Pharm.*, cxi, 257.

[*Note.*—It is easy to see that Bunsen's memoir contains the solution of many chemical and physical problems of great interest. Thus it is easy to produce at will a flame which shall have any required temperature, at least between certain limits. Since according to Bunsen's calculations (Gasometrische Analyse, p. 254) the flame of hydrogen burning freely in the air has a temperature of 3259° C., and that of olefiant gas has a temperature of 5413° C., we may as readily experiment at these temperatures as at 2300° C. Very much higher temperatures are of course produced when these gases burn with pure oxygen—in the case of hydrogen 8061° C.; in that of olefiant gas 9187° C. Hence by burning mixtures of these gases with oxygen and varying the proportion of nitrogen arbitrarily, we can make a scale of flames the temperatures of which shall range from less than 2000° C. up to at least 9000° C. and the melting point as well as degree of volatility of almost all metals and mineral substances may be thus assigned within quite narrow limits. It is easy to calculate the percentage of nitrogen or carbonic acid to be added in each case to the combustible gas in order to produce the required temperature. It appears probable that at high temperatures the radiating power of a body for heat is proportional to its radiating power for light. By directly comparing the intensity of the light radiated from platinum heated in a furnace with the intensity of the light radiated when the platinum is heated to a known temperature in a gas-flame, the temperature of the furnace might be approximately determined. Interesting results could also be obtained as to the exact temperature at which bodies become luminous and as to the relative quantities of light which different substances emit when heated to the same temperature, or the same substance at different temperatures. With respect to Bunsen's scale or series of minerals containing different but known proportions of soda I will suggest that perhaps a series of *glasses* could be made containing perfectly definite quantities of either soda or potash from 2 up to 20 per cent, so that each number would contain 2 per cent more alkali that the next lowest number. These would then serve as universal standards of comparison and give much precision to blowpipe observations.—W. G.]

W. G.

II. GEOLOGY.

1. *Review.—On some points in the Geology of the Alps.**—For nearly a century the great problem of the structure of the Alps has engaged the attention of geologists, and although much still remains to be done, we are gradually attaining to a clearer notion of the age and the mode of formation of this great mountain region. Among the most remarkable conclusions deducible from modern investigations is that of its very recent upheaval, and the age, geologically modern, of a large portion of its rocks. The great mass of nummulitic strata, with the overlying series of slates, limestones, marls, and fucoidal sandstones (once regarded as of transition age), which constitute the *flysch*, and belong to the eocene division of the tertiary rocks, has been upheaved vertically more than two miles, and penetrated by intrusive granites. Then took place the great movements of folding, inversion, and lateral and vertical displacement, the slow sinking of the northern side of the chain permitting the accumulation of the conglomerate of the *molasse* or the *nagelflue* (a formation partly freshwater and partly marine), which belongs to the miocene, and in part perhaps to the pliocene, and attains in some parts a thickness of from 6000 to 8000 feet. After the subsidence which allowed this vast accumulation, we find it raised by a vertical displacement of many thousand feet, and dipping towards the older rocks, so that the upper beds of the *nagelflue* seem to pass beneath the nummulitic limestones. (Murchison, *Quar. Jour. Geol. Soc.*, v, 241.) These great foldings and dislocations have often given rise to lateral movements by which the older strata have actually been forced over and made to rest unconformably upon younger rocks.

The Messrs. Rogers have shown that these great movements of the Alps present a close resemblance with those observed by them in the Alleghanies, and we are persuaded that a farther study of our older mountain chains, rendered more easy of investigation from the smaller number of formations involved, and from the regions being less elevated and more accessible, will throw still farther light upon the structure of the Alps and of mountain chains in general.

The vast thickness of the sedimentary deposits of secondary and tertiary age over the area now occupied by the Alps, when compared with their volume in other parts of Europe, serves to exemplify the relation which Prof. James Hall has so well pointed out, of the apparent connection of mountain elevations with original deposition (*Geology of Iowa*, i, 41). At the same time the weight of evidence now tends to show that the crystalline nucleus of the Alps, so far from being an extruded mass of so-called primitive rock, is really an altered sedimentary deposit more recent than many of the fossiliferous strata upon their flanks, so that the Alps as a whole have a general synclinal structure.

In the memoir before us the learned professor of geology in the Academy of Geneva, already well known by his researches in Alpine geology, has devoted himself to the study of a number of sections which exhibit

* *Memoire sur les terrains liassique et keuperien de la Savoie, par* Alphonse Favre. (Extrait du tome xv *des Memoires de la Société de physique et d'histoire naturelle de Genève*, 1859. Quarto, pp. 92, with three plates.)

the anthracitic and jurassic formations of Savoy. In these sections which he has given with lists of their organic remains, he includes (1) under the general name of the jurassic system both the oolitic or jurassic proper and the lias. Beneath these he distinguishes (2) a succession of limestones, chiefly dolomitic (*cargneules*), with interstratified beds of gypsum, underlaid by red and green marls and a silicious sandstone or arkose, the whole series, which attains a thickness of 2500 feet, being destitute of fossils, and reposing upon (3) shales and sandstones which enclose beds of anthracite and plants of the carboniferous epoch. Succeeding these comes the conglomerate of Valorsine (4), which, with the preceding group, he refers to the carboniferous system, while beneath all these are (5) reddish crystalline schists and gneiss, passing into a rose-colored protogine or talcose granite.

The third division is regarded by Favre as representing the *keuper* or triassic system, which, although known in the Tyrol and in Lombardy, has not hitherto been recognized in Savoy. Its identification is regarded by our author as highly important, inasmuch as it establishes a well defined geological horizon throughout this region. To the triassic system he refers the gypsums which are found encircling Mt. Blanc, and the salt deposits of Bex, of the Tarentaise, and elsewhere. Favre however recognizes the existence of more recent gypsums, with *cargneules*, in a fucoidal sandstone overlying the nummulitic limestone. The *cargneule*, which is here a constant associate of the gypsum, is according to the recent analyses of Marignac (p. 11) a cellular limestone or tufa containing about nine per cent of carbonate of magnesia, while the cells are filled with a nearly pure pulverulent dolomite. Massive, compact and crystalline dolomites are however frequently associated with these cargneules, which Haidinger conceives to have been formed by the alteration of dolomites under the influence of a solution of gypsum. We are however inclined to regard the cargneules as analogous to the tufas which we have elsewhere described as often associated with true dolomites. (This Journal, xxviii, 372.) To this subject we propose soon to return, but we take occasion to correct an error into which Mr. Favre has fallen in attributing to Sir William Logan the view that magnesian limestones owe their origin to the action of solutions of carbonate of soda upon sea-water (p. 42). This has arisen from an oversight in quoting from the *Literary Gazette*, where some observations made by us at the meeting of the American Association at Montreal in August, 1857, are reported in immediate connection with a paper of Sir W. E. Logan. We have endeavored to show that carbonate of magnesia has been formed in nature from the decomposition of soluble magnesian salts either by solutions of bicarbonate of soda or bicarbonate of lime, in the latter case sulphate of magnesia being concerned and sulphate of lime being also a product. (*Comptes Rendus de l'Acad.*, xlviii, 1003, and this Journal, xxviii, 170.)

Mr. Favre has not endeavored to identify the Permian system in this region, although according to Pidancet it occurs with its characteristic flora, beneath the variegated sandstones of the trias, in the adjacent department of the Jura. (*Bul. Soc. Geol. de Fr.*, [2], xii, 149.) The trias, according to our author, rests directly upon the shales and sandstones which are regarded by him as belonging to the carboniferous system, and

at other times upon crystalline schists, which however he suggests may be no other than the carboniferous rocks so highly altered as not to be distinguished from the older crystalline schists.

In the view which he takes of the relations of the jurassic and anthracitic rocks of the Alps, Mr. Favre is so completely at variance with most of those who have preceded him that it will be necessary to enter into some details with regard to this so-called anthracitic formation, which has been hitherto regarded as intercalated with and forming a portion of the jurassic system of the Alps. The conglomerate of Valorsine, which Favre classes with the palæozoic series, is according to Sismonda, no other than the *verrucano* of Savi, and the lowest member of the liassic series, beneath which at Jano in Tuscany is an anthracitic formation associated with a strictly palæozoic fauna. (Ibid, p. 635.) In various localities in Savoy, on the contrary, and particularly at Petit-Cœur in the Tarentaise and near Briançon, the anthracitic beds, consisting of sandstones and shales with impressions of ferns and layers of anthracite, appear to be intercalated in the jurassic system. This fact, announced by Élie de Beaumont in 1828, has been confirmed by a great number of subsequent observers, among which may be mentioned Sismonda, Murchison, Gras and Rozet. The fossil plants of this formation were by Brongniart and subsequently by Heer identified with those of the carboniferous system; according to Mr. Bunbury, who has since examined the fossils of Petit-Cœur, which are very much distorted and replaced by a film of talcose matter, their identification is difficult, and although some are undoubtedly carboniferous species, others are doubtful. (*Geol. Journ.*, v, xxix, 130.) Élie de Beaumont, with Murchison and Rozet, conceives that the evidence of the age of a formation furnished by fossil plants, to be far less reliable than that afforded by its fauna, and the latter imagines that during the jurassic period the climate may have permitted the development, upon islets in the midst of the sea, of a flora like that of the coal period. The observations of Elie de Beaumont in 1828 led him to refer the ferns and anthracites of Petit-Cœur as well as those of the neighborhood of Briançon to the summit of the lias. Both Gras and Sismonda distinctly recognize two horizons of anthracitic beds with fossil ferns, the one at the summit and the other at the base of the great anthracitic system; but while Sismonda (grounding himself upon the inferiority of the true coal formation to the conglomerate of Valorsine,) agrees with Elie de Beaumont and Murchison in regarding this system as really of jurassic age, although including a flora like that of the coal, Gras is inclined to look upon it rather as a formation of carboniferous age, with a liassic fauna, which has not however afforded a single palæozoic species.

Notwithstanding the concurrent evidence of so many observers to the fact of the intercalation of the anthracitic beds over a large area, with liassic fossils, there have not been wanting those who have endeavored to explain this association by supposed foldings, which may have involved the liassic beds with others belonging to an underlying carboniferous formation. This explanation, long since suggested by Voltz, was afterwards brought forward by Favre in 1841, since which time it has been discussed by various geologists, although generally with little favor. In

the present memoir our author examines the section of Petit-Cœur, and finds on one side, intercalated between the beds with belemnites and those containing ferns, a mass of cargneule which he considers the representative of the triassic system, separating the carboniferous and liassic series; the cargneule has not however been detected on the other side of the supposed fold, where the belemnite beds are in direct contact with the anthracite series. It might farther be objected that the mass of cargneule, the usual associate of gypsum, is not alone sufficient proof of the existence of the triassic system, since, according to Gras, gypsums accompanied by yellow altered limestones (in one case declared to be dolomite,) occur at two distinct horizons in the anthracitic series.

The observations of Mortillet on the section of Petit-Cœur are important; he not only concludes from his examinations that it is impossible to admit the existence of a fold in the strata at this locality, but asserts that the belemnites which underlie the fossil plants are different from those above. In the lower beds there is found but a single species, the *Belemnites acutus* (Miller), which as well as an associated ammonite, *A. bisulcatus*, belongs to the lower lias. In the beds above the coal fossils, on the contrary, there are several species of belemnites, not readily identified, but differing in form from that just mentioned, and apparently belonging to the middle or upper lias. He farther cites the existence in the same specimen of a belemnite and a fossil fern. (*Bull. Soc. Geol. de France*, [2], x, 18.)*

The testimony of Sir Roderick Murchison, after a minute examination of the section at Petit Cœur, is also most decisive as to the impossibility of admitting any folding or inversion of the strata, and he confirms the opinion of Élie de Beaumont and Sismonda as to the liassic age of the coal flora in question. As regards the vertical range of certain fossil plants he refers to a species of *Calamites* which extends from the carboniferous series through the permian and trias, and an *Equisetum* which is common in the trias of Germany and yet abounds in the oolite of England. (*Geol. Journal*, v, 178.)

In the Alps of Lombardy, Omboni has described a succession of rocks similar to that given by Favre; beneath the lias, according to him, are red and green marls with limestones containing the fossils of the muschelkalk, underlaid by red and green sandstones, the whole being referred to the triassic system. Lower still a series of limestones, dolomites and sandstones underlaid by black shales, the whole without fossils, and resting upon crystalline schists and protogines, is referred to the permian and carboniferous formations. These sandstones he considers as identical with the verrucano, which according to him contains in Tuscany the fossils of the coal period. (*Bull. Soc. Geol. de France*, [2], xii, 517.) We have already seen that Sismonda regards the verrucano as belonging to the base of the lias, and although associated with the anomalous liassic flora, as overlying the true palæozoic coal measures.

* For fuller details see Gaudry's sketch of the various papers on this subject, *Bull. Soc. Geol. de France*, [2], xii, 580 and 637. Sismonda, Ibid., p. 631. Rozet, *Memoire sur les Alpes Françaises*, ibid., 204; Gras, *Sur le terrain anthracifère des Alpes, Ann. des Mines*, [5], v, 475, and d'Archiac *Histoire de la Géologie*, vii, 107–157. Also Lyell, *Geol. Journal*, 1849, p. xxxviii, and Portlock, ibid., 1856, p. lxvii.

Connected with the view which supposes the continuation of a palæozoic flora up to the epoch of the lias is a question raised by our author (p. 29) regarding the association (established by comparison of considerable lists of species from various localities), of the fossils of the different stages of the lias in a single bed. Analogous cases are frequently met with at different geological horizons, showing that the causes which have limited the vertical range of certain animals are so far local, that under somewhat modified conditions the duration of a species may be prolonged after its disappearance from the adjacent seas. As our author has well said, it is in the continuation of similar chemical and physical conditions, generally dependant upon local accidents of the surface, that we must look for the cause of these apparent anomalies in the distribution of fossils. The investigations of Prof. Safford in Tennessee and Sir William Logan in Canada have made known a remarkable example of this in the Lower Silurian series of North America. In the State of New York the fauna of the Black River and Trenton limestones are almost totally distinct, so that the division between the two formations constitutes a well-marked palæontological horizon, while in Canada and in Tennessee the fossils of the two formations are so completely intermingled that it is impossible to distinguish between the Black River and Trenton limestones. (Billings, *Report Geol. Survey of Canada*, 1857, p. 152.) The genus *Catenipora* in North America also presents a remarkable instance of anomalous distribution; this coral throughout New York and Western Canada is Upper Silurian and is unknown below the Clinton Group, while at Lake St. John on the Saguenay it is abundant in the Black River limestone, a position which corresponds with its geological horizon in Europe.

The anthracitic system of the Alps has been described by Gras with great minuteness in the memoir cited above. He estimates the total thickness of the system at between 25,000 and 28,000 feet, and divides it into an upper and lower series, which are unconformable. The former with a thickness of about one-tenth of the whole, is referred to four subdivisions, and consists chiefly of argillo-calcareous shales terminated by a considerable mass of limestone, immediately beneath which occurs a bed of spilite, associated with gypsum and a yellow altered dolomite. The inferior division also consists in great part of similar shales, interstratified with gneissoid and talcose rocks to be noticed farther on; gypsum and a yellow altered limestone (dolomite?) also occur in this portion. In both the upper and lower divisions sandstones and shales are found with coal plants and layers of anthracite, the latter sometimes changed into graphite, while the associated calcareous shales contain in various localities, and at different horizons, belemnites and ammonites of liassic age.

Sismonda confirms the accuracy of the observations of Gras, and admits an upper anthracitic series, resting unconformably upon the lower, and of oolitic age, the lower only being referred by him to the lias proper, while Studer concludes the discussion of the subject as follows: "The intercalation of the lower anthracitic slates sometimes with gneissoid and talcose schists, and sometimes with the belemnitic shales, the layer of jurassic limestone which separates the lower from the upper anthracites, the extraordinary thickness of this calcareous layer and the anthracitic

zone which covers it, the presence of the verrucano (or talco-quartzose conglomerate) between these two formations and the quantity of talc disseminated in all these rocks, present us problems which science is not able to solve completely."—(Studer, cited by Laugel, *Bull. Soc. Geol. de France*, [2], xii, 576.)

In the metamorphic rocks of the anthracitic system Gras distinguishes what he calls a protogine or talcose formation, consisting of granite, gneiss and mica slates, generally more or less talcose, containing also schistose diorites, eurites and leptynites. This protogine formation is intimately associated with the argillo-calcareous shales of the lower anthracitic series, which are found interstratified with and even passing into gneiss and other feldspathic schists. Gras concludes that this somewhat irregular interpenetration of the two classes of rocks is due to an irregular metamorphism, portions of the argillo-calcareous sediments having, as he supposes, been profoundly altered by emanations from below, and he hence regards the protogine formation as a portion of the inferior anthracitic series. Similar crystalline schists also occur in some parts of the upper anthracitic series, and in both the upper and lower there are found serpentines, euphotides, porphyries and spilites, all of which the author regards as of sedimentary origin, and as having undergone *in situ* a profound metamorphism which has often effaced the marks of stratification; this view he declares is the only one which appears to agree with the observed facts. This protest against the theory of the igneous origin of serpentines is in accordance with the results obtained by the Geological Survey of Canada; in his report for 1848 Sir William Logan insisted upon the sedimentary origin of the serpentines which occur in the altered palæozoic strata of the Green Mountains.

Rozet, in his investigations of the Alps, has referred to the liassic and jurassic periods the great system of gneiss, with micaceous and talcose schists, which makes up Mts. Cenis and Pelvoux, and a great part of the mountains of the frontier of Piedmont, while, according to Fournet, the jurassic rocks of the Valais have been altered in like manner. (Coquand, *des Roches*, pp. 300–301.)

Our author however supposes that all these altered strata are of carboniferous age, and remarks that the fossils in the limestone of the lower lias show but slight marks of metamorphism, from whence he concludes that "in this region of the Alps there are no highly metamorphosed jurassic rocks," and that the metamorphic action "which took place beneath the sea before the elevation of these mountains" ceased to be powerful after the deposition of the Valorsine conglomerate, (which he regards as of carboniferous age,) the paste of which is often converted into a crystalline talcose schist. At the same, although the liassic and so-called triassic rocks are comparatively unaltered, the jurassic shales are described as more or less talcose and greasy to the touch, but the alterations of these argillaceous rocks our author regards "as rather mechanical than chemical." (p. 76.)

The question before us is then, whether in that series of rocks which embraces liassic and jurassic beds with gypsum, dolomite, anthracite, and a carboniferous flora, and which geologists have generally referred to one great system not older than the lias, we have really in these mountains,

as Favre supposes, the whole succession of formations from the oolite to the carboniferous inclusive, so involved by foldings and inversions that it has hitherto been impossible to determine their real structure.

But even if we admit with Favre the palæozoic age of the protogine formation described by Gras and Rozet, we cannot agree with him in limiting to the rocks of that period the action of the metamorphic process. The development of a talcose character in the jurassic shales we cannot regard as the result of a mechanical process, and we have besides evidences in the Alps of the metamorphism of still higher rocks.

As early as the year 1834 Keferstein had asserted that the granites of Mont Blanc are nothing more than altered strata of *flysch*, (*Naturgeschichte des Erdkörpers*, i, 286–292; *Bul. Geol. Soc. de France*, [1], vii, 198,) and in 1850 Sir Charles Lyell in his address before the Geological Society of London suggested that the protogines of the Alps might be of tertiary age. This is so far true that both Studer and Murchison have shown that portions of the eocene flysch have been converted into crystalline gneiss, mica slate and even granitic beds; Murchison, like Gras, whom we have already cited, remarks that the metamorphism seems irregular, some bands of the rock being apparently much more altered than others. (*Geol. Journal*, v, 164, 210.) The intercalation of wedge-shaped masses of fossiliferous limestone of liassic age among the gneissic strata of the Alps has been well described by Studer (*Bul. Soc. Geol. de France*, [2], iv, 208), and similar phenomena observed in various other metamorphic regions present a problem the right understanding of which is most important in its relations to the theory of metamorphism, and one which we propose to consider at an early day.

In conclusion we hasten to say, that although dissenting from some of the views of Mr. Favre, we are not less grateful for his very suggestive memoir, which with its carefully prepared lists of fossils and its beautiful sections is a valuable contribution to alpine geology.

T. Sterry Hunt.

2. *The Geological Structure of the "Jornada del Muerto," New Mexico, being an abstract from the Geological Report of the Expedition under Capt. John Pope, U. S. Top. Eng., for boring Artesian Wells along the line of the 32d parallel;* by G. G. Shumard, M.D., Geologist of the Expedition, (Trans. Acad. Sci. St. Louis, vol. i, No. 3, p. 341. 1859).—This paper gives a description of the geological structure of a district of country lying immediately east of the Rio Grande, and between the 32d and 34th parallels. The "Jornada del Muerto" is described as a gently sloping plane, of an elliptic form, from twelve to forty miles in breadth, and extending from near the southern extremity of the Doña Ana Mountains eighty or ninety miles in a N.N.W. direction. It is bounded on the east and west by ranges of mountains, varying in their elevation from two or three hundred to one thousand feet above the plane, and seem to be mainly composed of dark colored limestones of Upper Carboniferous age, dipping towards the interior of the intermediate plane; these rocks however, in the western range, were observed at some places, surmounted by shales and sandstones referred to the Cretaceous epoch. Igneous rocks form a belt of low hills along the eastern side of the eastern range, and also occur between the other and the Rio Grande. From the structure of

the surrounding country, the "Jornada" is supposed to be a great synclinal depression, in which water could probably be obtained by artesian borings, through heavy detrital deposits.

The fossils found in the Carboniferous rocks here, and in the Organ Mountains, are all Upper Carboniferous types, many of them being identical with species almost everywhere common in the western Coal Measures. Those mentioned in the Cretaceous beds are *Inoceramus* and *Cardium*. The paper also contains interesting local details in regard to the igneous and metamorphic rocks of the several mountain ranges explored. M.

3. *Notice of Fossils from the Permian strata of Texas and New Mexico, obtained by the United States Expedition under Capt. John Pope, for boring Artesian Wells along the 32d parallel, with descriptions of new Species from these strata and the Coal Measures of that region;* by B. F. SHUMARD, M.D., (Trans. Acad. Sci. St. Louis, vol. i, Part 3d. 1859).—This is an important paper, containing descriptions of many new species, with an enumeration of others identified with forms known in the Kansas rocks, and of a few which are, by the author, supposed to be identical with foreign species; it is also illustrated by an excellent plate of twenty-seven figures by Leopold Gast & Brother of St. Louis.

Most of these fossils are from an extensive deposit of white limestone, and inferior beds of sandstone and darker colored limestone, in the Guadalupe Mountains, referred by Dr. S. to the Permian System. The new species described from these rocks are—

Campophyllum? Texanum, Chonetes Permiana, Spirifer Guadalupensis, Terebratula perinflata, Rhynchonella indentata, R. Texana, Camerophoria Swalloviana, Crania Permiana, Axinus securis, Turbo Guadalupensis, Pleurotomaria Halliana, and *Chemnitzia Swalloviana.* Those from the beds regarded as Carboniferous, are *Turbo Texanus, Straparollus cornudanus, Pleurotomaria Proutiana, P. obtusipira, P. perornata* and *Machrocheilus Texanus.*

All of which appear to be described with the author's well known care and accuracy.

Dr. S. had previously described from the beds he places in the Permian,

Phillipsia perannulata, Fusulina elongata, Productus Mexicanus, P. pileolus, P. Popei, Strophalosia (Aulosteges) Guadalupensis, Spirifer Mexicanus, S. sulciferus, Spiriferina Billingsii, Terebratula perinflata, Rhynchonella Guadalupæ, Camerophoria bisulcata, Retzia papilata, R. Meekiana, and *Myalina recta,*—

several of which are well illustrated in the plate accompanying the paper now under consideration. He also gives the following list of forms from these rocks, regarded by him, with more or less confidence, as identical with species occurring in the Permian and Upper Carboniferous beds of Kansas, viz:

Acanthocladia Americana, Productus Calhounianus, P. Norwoodii, Spirifer cameratus, Streptorhynchus (Orthisina) Shumardianus, Edmondia suborbiculata, and *Pleuraphorus occidentalis;* while he thinks he recognizes the following foreign species in the same association:—*Chætetes Mackrothii, Productus semireticulatus,* var. *antiquatus, P. Leplayi?, Terebratula elongata, Camerophoria Schlotheimi?, Myalina squamosa, Monotis Speluncaria,* and *Turbo helicinus?.*

As Dr. S. finds a *Phillipsia* and a *Fusulina*, in these rocks, neither of which genera are known to range up into Permian beds in the old world, and *Spirifer cameratus* is a characteristic Coal-measure species, from Pennsylvania to the Rocky Mountains; while *Productus semireticulatus,*

is regarded by most authors as peculiar to the Carboniferous system—and a large proportion of the other species mentioned as common to the New Mexican and Kansas rocks, are known to occur in the latter territory in beds containing even a majority of well marked Coal-measure species, we may infer that in New Mexico, as in Kansas, there is a considerable blending of Carboniferous and Permian types; so that it becomes a matter of doubt and difficulty to determine at what particular horizon the line of demarkation should be drawn between these two Systems, if indeed there is any such natural break in our upper Palæozoic series of this country. It is to be hoped Dr. S. will continue his investigations of the fossils occurring in these formations, which he will doubtless have an opportunity to do, in connection with the geological survey of Texas, under his charge. M.

4. *Observations on the Geology of the County of Ste. Geneviève, being an extract from the Report made to the Missouri Geological Survey, in* 1859; by B. F. SHUMARD, M.D., (Trans. St. Louis Acad. Sci., vol. i, part 3, page 404, 1859.)—In addition to information respecting the iron and lead mines, building materials, &c., of the county, this extract contains some facts having an important bearing on mooted points in the classification of the Lower Carboniferous Series of the West. Dr. S. found this series to be composed of the following members, in the descending order:

1st. THE UPPER ARCHIMEDES LIMESTONE, characterized by *Pentremites pyriformis, P. sulcatus, Agassizocrinus dactyliformis, Spiriferina spinosa, Spirifer trigonalis*, and species of *Archimedipora*.

2d. THE FERRUGINOUS SANDSTONE, in which no fossils were found,—estimated thickness, 80 to 100 feet.

3d. THE STE. GENEVIEVE LIMESTONE, a second Archimedes bed, in which the following fossils were found:—*Rhynchonella trimela, R. Wortheni, Spirifera hirsuta, Retzia Marcyi, Spiriferina spinosa, Spirifera Leidyi, Productus elegans, P. bisulcatus, Murchisonia vermicula, Pentremites florealis*, and one or more species of *Archimedipora*.

4th. THE SAINT LOUIS LIMESTONE—containing *Lithostrotion mammillaria, Archæocidaris* and *Pentremites conoides*,—thickness 100 feet or more.

5th. THE THIRD ARCHIMEDES LIMESTONE, containing *Pentremites laterniformis, P. conoides, Archimedipora, Dichocrinus simplex, Spirigera hirsuta, Productus Indianensis, Rhynchonella subcuneata*, and *Holopea Prouti*,—thickness from 100 to 150 feet.

6th. THE ENCRINITAL LIMESTONE (= BURLINGTON LIMESTONE), with its usual fossils—being the lowest member of the great Carboniferous series.

Of the Devonian rocks he recognizes the CHEMUNG GROUP, HAMILTON GROUP, and the ORISKANY SANDSTONE. Of the Silurian—1st. LOWER HELDERBERG SERIES, 2d. The NIAGARA GROUP, 3d. The HUDSON RIVER GROUP, 4th. The RECEPTACULITE LIMESTONE, 5th. The TRENTON LIMESTONE, 6th. The BLACKRIVER and BIRDSEYE LIMESTONES. Then comes the five members of the GREAT MAGNESIAN LIMESTONE SERIES, which represents the Calciferous, and possibly portions of the Potsdam and Chazy Limestones of New York; and last of all, eruptive rocks.

Of the Coal measures, only thin outliers cap the hills half a mile above St. Mary's on the Mississippi. The beds are alternations of shale and sandstone, surmounted by a thin bed of hard siliceous limestone. M.

5. *Third Series of Descriptions of Bryozoa, from the Palæozoic Rocks of the Western States and Territories;* by H. A. PROUT, (Trans. Acad. Sci. St. Louis, vol. i, part 3, p. 443, 1859.)—Every geologist who has

worked amongst western rocks, must have regretted that Palæontologists have generally given so little attention to the remains of *Polyzoa* characterizing these formations. These delicate forms of life existed in great profusion during portions of the Palæozoic era, especially during the deposition of some of the lower members of the great Carboniferous series, and are often met with in a good state of preservation, where no other organic remains are to be seen. Consequently when accurately classified, and the species and genera are fully described and illustrated,—due care being taken to determine the exact geological position of each,—they will at once become an important guide in the identification of strata.

The task of classifying, describing, and illustrating these remains occurring in the western rocks, has been undertaken by Dr. Prout of St. Louis, who has produced several valuable papers on this subject, previous to the publication of that now under review. His last paper, mentioned at the head of this notice, contains full descriptions of nine new species, and two new genera, with four beautiful plates illustrating these and some of the species described in his former papers. These plates are engraved on stone by Leopold Gast and Brother, of St. Louis, from drawings by Dr. Prout and Mr. Gast, and bear evidences of skill and accuracy. The new genera described in this paper are *Semicoscinium* and *Septopora*, and the new species, *Semicoscinium rhomboideum*, *Fenestella hemitrypa*, *F. banyana*, *Limaria falcata*, *Flustra spatula*, *F. tuberculata*, *Septopora Cestriensis*, and *Polypora tuberculata*.

Dr. S. also thinks he has identified a Permian species, *Polypora biamica* of Keyserling, in the Upper Archimedes Limestone, a member of the Lower Carboniferous Series,—at any rate no essential differences were observed in the specimens compared. It is probable however, that when better specimens are obtained, showing all the characters of this Lower Carboniferous form, it will prove distinct from the Permian species. M.

III. BOTANY AND ZOOLOGY.

1. *Collections of Cuban Plants.*—Mr. Charles Wright revisited the eastern part of Cuba in the autumn of the year 1858, where he still remains, engaged in botanical explorations in that little-known region. His collections of dried plants, up to last autumn, have already been received; and the Ferns, which form a large and very attractive part of them, have been distributed into sets. A number of these sets, not yet appropriated, are offered for sale. The fullest of these sets contain about 180, the smallest 120 species, which may be increased by further collections to a moderate extent. Sets can be obtained from Professor Gray, Cambridge, at $10 per hundred specimens. Of phænogamous plants, soon to be distributed, a very few sets are still open to subscribers, at the same price. It is expected that the species will be named very soon. The names of the ferns are about to be published by Mr. Eaton of New Haven, our principal Pteridologist. The rich collections in the lower *Cryptogamia*, made by Mr. Wright in his former visit to Cuba, along with those of the present exploration, are now in course of study, the *Musci* and *Hepaticæ* by Mr. Sullivant, the *Lichenes* by Prof. Tuckerman, the *Fungi* by the Rev. Dr. Curtis, preparatory to their distribution in

named sets. Those who desire to secure full sets should make early application to Prof. Gray, who will have them in charge during Mr. Wright's absence. A. G.

2. *Systematic Arrangement of the Species of the Genus Cuscuta, with critical remarks on old species, and descriptions of new ones;* by GEORGE ENGELMANN, M.D. (Extr. from Trans. Acad. Science of St. Louis, vol. i, pp. 453–523; separate issue pp. 73,) 8vo, 1859.—It is well known to botanists that Dr. Engelmann has for many years been making a special study of *Cuscuta*, and that, besides his own and other American collections, those of the principal European herbaria have been rendered to him for examination. His recent visit to Europe enabled him to extend and to revise his study of this genus. The study of the *Coctaceæ* of North America, which so long interrupted the former investigation, having been brought to a conclusion, Dr. Engelmann has at length been able to publish his revision of the whole genus *Cuscuta*. The thirty-eight species more or less known to Choisy when he elaborated this genus for the Prodromus are doubled in the present enumeration, although an equal number, including several of Choisy's, and of his own formerly proposed, are reduced to synonyms, or arranged as varieties. Many species prove to be remarkably polymorphous, and require an array of varieties and subvarieties to express their manifold diversities in systematic form. The work has involved immense labor, and bears the marks throughout of the most patient and conscientious treatment. Sound views prevail in the generalities as well as in the details; the Linnæan genus is preserved intact, but disposed in three primary groups or subgenera,—*Cuscuta* proper, *Grammica*, and *Monogyna*, and these in nine sections. The species of the first group are all indigenous to the Old World; those of the second are mostly American and Eastern Asian; of the third principally Asian, but two species extend into Europe, one is Texan, and one South African. A. G.

3. *On the Distribution of the Forests and Trees of North America, with Notes on its Physical Geography;* by J. G. COOPER, M.D. pp. 40, 8vo. Extr. from the Report of the Smithsonian Institution for 1858.—The tables illustrating the geographical distribution of our trees and larger shrubs bring together and systematize a great amount of valuable information. As a first essay, it appears to be all that could be expected; and the author himself, having taken up the subject with great zeal and good opportunities, will doubtless perfect it in the future reports for which he is collecting materials. Since the catalogue purports to be one of the *trees* of the United States, we should not have included shrubs, except those of the largest class, and a few which belong to genera characteristically arboreous, such as *Quercus*, *Acer*, &c. Such depressed shrubs as *Prunus maritima* and *Cerasus pumila* are surely out of place. The incongruity is all the more serious in the catalogue of the trees of the regions of the Rocky Mountains and westward, which regions being "comparatively poor in trees," the standard is there still farther reduced, "since shrubs become more valuable where trees diminish in number." This confusion of economical with scientific considerations has the effect of representing the western part of the continent to be far richer in trees than it really is. Of the 108 species in this list only a moiety would

seem to make good their claim to be called forest trees, or trees at all. And in this connection we venture to suggest that the *minimum* as well as the *maximum* height which the trees attain should be given. The *average* height is the more important to be known; the maximum is rather a matter of curiosity. "The reason for giving the maximum heights [only] is, that it is thought the cultivation of trees will become some day a matter of national interest, and I wish to show what they are under the best natural circumstances, supposing that, with cultivation, they will at least equal this standard." We do not suppose so. Under the *same circumstances*, the Lambert-pines of future ages might indeed aspire to 300 feet in height, and the giant *Sequoia* to 450 feet; but planted trees, with room to spread as they should, are never drawn up as in primæval forests.

The delineation of *natural provinces* and *regions* in North America, according to the distribution of our arborescent vegetation, opens wide questions upon which we must not here enter. We should incline to broader views and fewer subdivisions, as preferable for exhibiting the general facts of the case, and more likely to be stable.

The Floridian region is said to have "about thirty-two characteristic and thirteen peculiar trees," and accordingly would appear to be far more strongly marked than any other of the nine. The erroneous impression which this may give would be removed by an expansion of the statement that "Florida appears rather to belong to the West Indian province." Nearly all these peculiar or characteristic trees belong to the Keys, and are Bahaman or West Indian species. Probably no other part of North America is really so destitute of peculiar species of plants as southern and eastern Florida.

In conclusion, while we heartily thank Dr. Cooper for this interesting and useful essay, and expect still better results from his continued investigations, we simply enter a protest against the anachronism of appending an early author's name to a species under a genus which he never heard of, and against the bad taste of writing the names of persons without a capital initial,—both innovations from which botanical writings have thus far been nearly free. A. G.

Zoological Notices.—

1. Prof. J. Victor Carus, of Leipsic, writes to the Smithsonian Institution, July 27, 1859, as follows: "During the last two years, I have been collecting materials towards a general catalogue of zoological literature, from 1750 up to the present day, including not only all the separately published works, books and pamphlets, (most of which are to be found in Engelmann's Bibliotheca Historico-Naturalis,) but also, and especially, all the papers, articles and notices contained in periodicals, the number of which is increasing every year. All the titles and references will be arranged systematically, not according to the alphabet of the authors, but within the classes and groups according to the alphabet of the genera; so that at a glance one will find the whole literature of any particular genus." Prof. Carus calls for aid in obtaining access to American scientific papers, many of which are found in periodicals which are difficult to obtain, as he wishes to make his work as nearly complete as possible. Any who wish to further his laudable object would confer a favor by forward-

ing to him synopses of the contents of the more obscure publications, copies of minor papers, etc.

2. *Die Klassen und Ordnungen des Thier-Reichs, wissenschaftlich dargestellt in Wort und Bild.* Von Dr. H. G. Bronn, Prof. an der Univ. Heidelberg. Leipsic and Heidelberg; C. F. Winter, 1859. 8vo. with plates.—Of this excellent work now in the course of publication, five parts have appeared, containing the Amorphozoa and part of the Actinozoa. The subject is treated in a masterly manner, and the work will undoubtedly be far more complete in its character than any general treatise on Zoology yet published. It commences with an introduction, giving a short general account of the nature of the Animal Kingdom, a history of its investigation by zoologists, and a tabular view of the characteristics of the five subkingdoms, (which are named Amorphozoa, Actinozoa, Malacozoa, and Entomozoa and Spondylozoa,) in regard to their radical form, radical number, embryonic development with reference to the "Primitive-Theil" and position of the yolk, organic system, the head, nervous system, structure of skeleton, teeth, circulatory system, and blood.

In the body of the work each class is treated of under the following heads: I. Introduction, an account of the name and literary history of the class; II. Organic structure; III. Chemical composition; IV. Vitality, and Embryology or Development; V. Classification; VI. Geographical and Topographical Distribution; VII. Geological evolution; and VIII. Signification in the Economy of Nature. In the *Introduction* a full bibliography is given for each class. Under the head of *Classification*, a systematic review or synopsis is given of the sub-classes, orders, suborders, families, sub-families, relationships, (sippschaft) and genera, (sippen); more than the usual number of subdivisions being introduced. In this synopsis, such characters only are given as are necessary to discriminate between known genera, but the work is carefully brought up to the present state of the science in a more thorough manner than has been attempted before in any general work. Some useful abbreviations are introduced which will tend to a convenient shortening of descriptions, although it would have been perhaps better to have formed them from Latin rather than German words. (See p. 44, Vol. II.) The plates are well done, and illustrate not only the structure and development, but a considerable number of the generic forms of each class. The wood-cuts are less remarkable for artistic excellence. W. S.

3. *Description of Oceania* (*Turritopsis*) *nutricula, n. s. and the embryological history of a singular Medusan Larva found in the cavity of its bell;* by Prof. John McCrady, (Proc. Elliott Soc. Nat. Hist. of Charleston, S. C., vol. i, p. 55–90); and *The Gymnophthalmata of Charleston Harbor;* by the same author. (Ibid., i, p. 103–221. Plates 4–12.)—These articles, particularly the latter, form the most valuable contribution to the history of our American *Hydroidea* that has appeared since Agassiz' papers in the Memoirs of the American Academy. Like the latter, they are written in that easy, interesting style which is so much more agreeable to the reader than the dry description of details which constitutes the bulk of biological writings. The author has put forth some new views, and enlarged upon the suggestions of his predecessors, in a manner well worthy of the attention of scientific zoologists.

Prof. McCrady states that there is no essential difference between the so-called alternation of generations and a regular metamorphosis, which he calls a *homogony*, after Gegenbaur. The hydroid larvæ therefore of the Gymnophthalmata should no longer be separately named and described, but their history should be included in that of the species to which they belong, as is done in the case of Insects. For the group the name *Hydroidea* is retained, following the rule of priority, *Cryptocarpæ* of Eschscholtz being rejected on account of its erroneous significance. In subdividing the group the author seizes upon an excellent character, founded upon the mode of growth in the medusa-buds, which has been overlooked by previous investigators. In *Tubularia*, *Coryne*, etc., the outer covering of the bud becomes the disc of the medusa, and the digestive tube is enclosed from the first. In *Campanularia* and its allies, on the contrary, the digestive tube projects at first freely from the bud, and becomes afterward enclosed by the over-arching disc, which grows outward from its base. Upon this ground the Hydroidea are separated into two sub-orders—*Endostomata* and *Exostomata*. This subdivision is confirmed by characters derived from the full-grown Medusæ:—in the first group these are deeply bell-shaped, sometimes even sub-cylindrical, with no sinuses in the radiating tubes, and a long digestive cylinder pendant from the disc; in the second they are generally broad and shallow, or saucer-shaped, with many sinuses in the radiating tubes, and a short digestive cavity imbedded in the disc. In the former group are included the Corynidæ, Velellidæ, Tubularidæ and Siphonophoræ. Recent investigations have shown that the Velellidæ and Siphonophoræ are true Hydroidea and the free medusa (*Chrysomitra*) of Velella has been observed and described by Huxley, Vozt, Kolliker and others. The development of the medusa-buds in these two families is after the manner of the Endostomata. In the latter group, Exostomata, the author includes the Campanularidæ, Sertularidæ and Æginidæ, with several genera the family connections of which are uncertain.

In the description of the Hydroidea of Charleston Harbor, Prof. McCrady has more than doubled the number of species known to exist on our shores. He describes 32 species belonging to 30 genera, 8 of which are new, as follows;—among the Endostomata, *Turritopsis*, *Corynitis*, and *Dipurena*; among Exostomata, *Encheilota*, *Entima*, *Epenthesis*, *Phortis*, and *Persa*. In the genus *Nemopis* the author has failed to discover the ocelli described by Agassiz as existing in the tips of the upturned tentacles, and says that the darker hue of these tips is occasioned by their greater thickness. The *Globiceps tiarella* of Ayres (*Eucoryne elegans*, Leidy) is found in Charleston Harbor, and is placed in the genus *Pennaria* by Prof. McCrady, who describes its medusa. The parasitic medusa found in the bell of *Turritopsis nutricula*, and described in the first paper as the young of that species, is afterward considered to be the young of a *Cunina*. The paper closes with a discussion of the geographical distribution of the American Hydroidea. W. S.

4. *On the zoological affinities of Graptolites;* by Prof. JOHN MCCRADY. (Proc. Elliott Soc. Nat. Hist., i, p. 229.)—These paradoxical fossils are regarded by Prof. McCrady as similar to the toothed rods of the larvæ of Echinoderms, described by Joh. Muller. The great discrepancy in size

he explains by suggesting that these embryo-like forms were fully developed animals characteristic of the early geological period at which they existed. W. S.

5. *Letters from Alabama, chiefly relating to Natural History;* by PHILIP HENRY GOSSE, F.R.S. London, 1859, pp. 306: small 8vo.—Another popular scientific work of this prolific writer. It consists of a series of letters written many years ago, when the author was teaching school in the interior of Alabama. In his usual interesting style, Mr. Gosse describes the habits and points out the beauties of many of our Southern plants, insects, reptiles and birds, with numerous illustrations on wood. W. S.

6. *Sketch of a revision of the genera of Mithracidæ;* by WM. STIMPSON.—The old genus *Mithrax* was divided into three groups by Milne-Edwards, (Hist. Nat. des Crust., i. 318), *Mithrax triangulaires*, *M. transversaux*, and *M. déprimés*. These groups are now considered of generic value. For the first group De Haan has proposed the name *Dione*, which cannot however be adopted, as it was previously applied to a genus of Lepidoptera, by Hübner. It is also used for a bivalve shell. To the third group White gave the name *Mithraculus*, which was adopted by Dana.

In the Proceedings of the Zoological Society of London, 1847, p. 222, Mr. Adam White gives a wood-cut of a maioid crustacean, to which he applies the name *Schizophrys*, with the following description: "Carapax oval, depressed, somewhat attenuated behind; beak deeply cloven; upper orbit deeply cloven, with a strong tooth in the middle of the cleft; under orbit an elongated appendage on the inside, with two teeth at the end. Tale of male with 7 joints, the sides nearly parallel. Fore-legs shortest. Fingers without teeth." This genus, in the catalogue of the British Museum, is placed between *Othonia* and *Pericera*. But if we consider that by the "elongated appendage on the inside" of the orbit, Mr. White probably means the basal joint of the external antennæ, and observe how closely the figure corresponds to young crabs belonging to De Haan's genus *Dione*, the conclusion is unavoidable that *Schizophrys* is really synonymous with the *Mithrax triangulaires* of Milne-Edwards, and as such we here adopt it. In the following synopsis new characters are introduced; some new genera are described, and a list given of the species known up to the present date.

A. Maxillipedis externi merus margine antico integer.

MITHRACULUS, White. (*Mithrax*, pro parte, De Haan, Fauna Jap. Cr. 82.) Carapax depressus, rostro brevissimo vel nullo.—*M. sculptus*, (M.-Edw.,) *M. nodosus*, (Bell,) *M. denticulatus*, (Bell,) *M. coronatus*, (Herbst.) *M. cinctimanus*, Stm.

B. Maxillipedis externi merus angulo antero-interno excisus, ad palpum incipiendum.

a. Frons angusta. Orbitæ parvæ, profundæ, oculos pæne operientes, MITHRAX, Leach. Carapax plus minusve transversus. Orbita multifissa, margine dentibus vel tuberculis armata.

1. Antennæ externæ articulus basalis spinis tribus armatus.—*M. verrucosus*, M.-Edw., *M. aculeatus*, (Herbst.)

2. Antennæ externæ articulus basalis spinis duabus armatus.—*M. spinossissimus*, (Lamk.), *M. hispidus*, (Herbst,) *M. ursus*, Bell, *M. rostratus*,

Bell, *M. pygmæus*, Bell, *M. cornutus*, De S., *M. armatus*, De S., *M. tuberculatus*, Stm.

Teleophrys, nov. gen. Carapax antice triangularis, postice et lateraliter rotundatus, sulco cervicali sat profundo. Orbita margine supero externoque integra, nec dentata.—*T. cristulipes*, Stm.

b. Frons lata. Oculi majores. Orbitæ grandes, non profundæ, late fissæ, oculos non operientes.

Schizophrys, White. (*Dione*, De Haan.) Carapax ovato-triangularis. Rostrum longum, bifidum, cornibus bidentatis.—*S. dichotoma*, (Latr.) *S. affinis*, (De Haan,) *S. aspera*, (M.-Edw.), *S. serrata*, White, *S. spinigera*, White, *S. dama*, (Herbst.)

Cyclomaia, nov. gen. Carapax orbiculatus, antrorsum quam retrorsum vix angustior. Rostrum brevissimum, bifidum, cornibus acutis, non dentatis. Oculi grandes, sat breves. Antennæ externæ articulus basalis trispinosus, spinis superne conspicuis. Maxillipidis externi merus apice interno profunde sinuatus. Pedes mediocres.—*C. suborbicularis*, Stm.

Cyclax, Dana. *Cyclomaiæ* carapacem affinis. Oculi longi; pedes longi, tenues.—*C. Perryi*, Dana.

Mithraculus, *Mithrax*, and *Teleophrys* are American; *Schizophrys*, *Cyclomaia* and *Cyclax*, old-world types.

7. *Archiv für Naturgeschichte*, vol. xxiv, for 1858; Berlin, 1859:—contains the following articles of special interest:—Anatomy and development of Copepoda, with 2 plates; *Claus.*—Descriptions of new Chilian Vertebrates by *Dr. Philippi.*—Revision of the Gadidæ, Soleinæ, and Plagusinæ; *Kaup.*—(Mr. Kaup considers our *Morrhua pruinosa* and *M. americana* as one species and identical with *M. vulgaris!*)—Geographical and historical remarks on certain mammals; *Martens.*—On the species of Velutina; *Martens.*—On Annelides of the Brazilian Coast, 2 plates; *F. Müller.*—Enthelminthica, 2 plates; *Wagener.*—Anatomy and Histology of some Trematodes; *Walter.*—New Batrachians, *Günther.*—On the hard-cheeked Acanthopterygians; *Kaup.* (The number of genera very much reduced.)—Critical remarks on Castelnau's Siluroids; *Kner.*

W. S.

8. *The Natural History Review and Quarterly Journal of Science*, a periodical published at London and Dublin, containing reviews of works relating to Natural History, and also the proceedings of the Dublin Scientific Associations, as follows:—the Geological Society, the Natural History Society, the University Zoological and Botanical Association, the Royal Irish Academy, and the Royal Society. In giving a synopsis of the more important zoological papers read before these five Associations, we shall, for the sake of convenience, cite the "Quarterly Journal" instead of their own regular publications:—

Vol. v. 1858, contains—p. 134, On new genera and species of Polyzoa, 4 plates; *W. Thompson.*—p. 148, Cambrian fossils, Histioderma, n. g. (annelide); *Kinahan.*—p. 168, Steropis, a new genus of Carboniferous Crustacea, allied to Limulus; *Baily.*—p. 194, On some Oniscoidea, with a plate, *Kinahan.*—p. 202, New forms of Diastylidæ (wood-cuts); *Bate.*—p. 207, On Oldhamia, a Cambrian fossil; *Kinahan.*—p. 276, Ancient and modern races of Oxen in Ireland, (wood-cuts); *Wilde.*—Vol. vi., 1859, p. 108, On the urticating organs of Actinia; *M'Donnell.*—p. 113, Irish

—p. 191, Crimean Fossils; *Bailey.*—p. 199, New Irish Orthocerata; Actiniadæ; *Wright.*—p. 125, Platyarthrus, Brandt, and allied genera; *Kinahan.*—p. 152, Anatomy of the brain in some small Quadrupeds, 2 plates; *Garner.*—p. 161, Subterranean Gammaridæ; *Bate* and *Hogan. Haughton.*—p. 237, Morphology of the Hydrozoa, with reference to the constitution of the sub-kingdom Cœlenterata; *Greene.* (Mr. Greene includes the Lucernaridæ with Hydrozoa, and considers the Medusidæ—"Animal consisting of a polype suspended from the under surface of a natatorial organ"—an order distinct from the Hydridæ and Tubularidæ!)

9. *An essay on Classification*, by Louis Agassiz.—This work, forming the introduction to Prof. Agassiz' Contributions to the Natural History of the United States, has been published in a separate form, a convenient octavo, by the Longmans and Trübner & Co., London.

10. *On the genus Synapta;* by Woodward and Barrett, (Proc. Zool. Soc. of London, xxvi, 360. Plate xiv).—A short historical and anatomical account of the interesting family of Holothurians in whose skin are found the miniature anchors and wheels, which form such elegant objects for the microscope. They give detailed descriptions of *Synapta digitata* and *S. inhærens*, and add one new species, *S. bidentata*, from China. They also give what purports to be a list of the known species of the family, to which, however, the following should be added:—*Synapta oceanica* Less., *S. doreyana* Quoy and Gaimard, *S. punctulata* Q. & G., *S. bachei* Pourt., *S. tennis* Ayres, *S. pellucida* Ayres, *S. dolabrifera* Stm., *Chirodota fusca* Q. & G., *C. rubeola* Q. & G., *C. tenuis*, Q. & G., *C. rufescens* Brandt, *C. rotifera* Pourt., *C. pallida* Ayres, *C. australiana* Stm., *C.* (*Myriotrochus*) *brevis* Huxley. W. S.

Proceedings of the Elliott Society of Natural History of Charleston, S. C.—Vol. I. 1856.—p. 50, On Cicadæ; *J. Lee.*—New and rare Phænogamous Plants found in the State of South Carolina; *H. W. Ravenel.*—p. 55, Description of Oceania (Turritopsis) nutricula, nov. sp., and the embryology of a Medusan Larva found in its bell; with four plates; *J. McCrady.*—1857, p. 91, On the past and present condition of Ningara Falls; *L. R. Gibbes.*—p. 101, Notice of an ore of Argentiferous Galena; *Frampton.*—p. 102, On the fruit of Yucca gloriosa; *L. R. Gibbes.*—p. 103, Gymnophthalmata of Charleston Harbor, with five plates, (noticed in this Volume, p. 130); *J. McCrady.*—p. 222, On Specific Form; *J. McCrady.*—p. 223, On a Bolina found in Charleston Harbor; *J. McCrady.*—p. 225, Description of Ranilia muricata, M. Edw., with a plate; *L. R. Gibbes.*—p. 229, On the zoological affinities of Graptolites (noticed in this volume, p. 131); *J. McCrady.*—p. 237, Gigantic Orthoceras from Minnesota; *L. A. Frampton.*—p. 238, On a Cactus from Eding's Bay, S. C.; *L. R. Gibbes.*—p. 239, Medusæ of Port Royal Harbor, S. C.; *J. McCrady.*—p. 241, Botany of Eding's Bay; *L. R. Gibbes.*—p. 251, Preparation of Metallic Cobalt; *W. Sharswood.*—p. 254, Development of two species of Ctenophora found in Charleston Harbor, with a plate; *J. McCrady.*—1858, p. 272, Cacti of S. Carolina; *L. R. Gibbes.*—p. 275, Instance of incomplete longitudinal fission in Actinia cavernosa; *J. McCrady.*—p. 278, A new locality for Rutile; *W. Sharswood.*—p. 280, Three new Univalves; *E. Ravenel.*—p. 282, New genus of fossil Echini, Ravenelia, allied to Pygorynchus; *J. McCrady.*—p. 287, Antidote for Arsenious Acid; *W. Sharswood.*—p. 288, Phenomena of the Earthquake of Dec. 19, 1857; *L. R. Gibbes.*—p. 291, On a convenient form of Aspirator; *L. R. Gibbes.*

Proceedings Boston Soc. Nat. Hist., 1859.—p. 49, On the priority of discovery of the fossil footmarks of the Connecticut Valley; *T. T. Bouvé.*—p. 54, Trilobite from Newfoundland; *C. T. Jackson.*—p. 58, Japanese plant-wax; *W. B. Rogers* and *C. T. Jackson.*—p. 60, On the Infusorial deposit in the Tertiary of Virginia and Maryland; *W. B. Rogers.*—p. 64, Mineral resources of the Rocky Mountain Chain;

W. P. Blake.—p. 74, On the frozen well of Brandon, Vt.; *C. Stodder.*—p. 75, Paradoxides Harlani, *C. T. Jackson.*—Habits of marine animals observed at West Yarmouth, Mass.; *T. Lyman.*—Diatomaceæ from Milwaukee; *A. M. Edwards.*—p. 81, Report on the frozen well at Brandon, Vt.; *Jackson* and *Blake.*—p. 89, On collecting, preparing and mounting Diatomaceæ; *A. M. Edwards.*—p. 102, A list of Birds seen at the Bahamas, from Jan. 20th to May 14th, 1859, with descriptions of new or little known species; *H. Bryant.*

Proceedings Philadelphia Acad. Nat. Sci., 1859.—p. 162, On fossil teeth and bones collected by Prof. Emmons: Ontocetus Emmonsi, nov. sp., founded on the tooth of a Cetacean; *J. Leidy.*—Notice of Humboldt; *I. Lea.*—p. 164, On a specimen of Hydaticus zonatus; *C. A. Helmuth.*—p. 165, Description of new generic types of Cottoids from the Collection of the North Pacific Expedition; *T. Gill.*—p. 167, Description of a new species of Callianidea; *T. Gill.*—p. 168, Entomacrodus, a new genus of Salarianæ; *T. Gill.*—p. 169, Herpetological Notices; *C. Girard.*—p. 170, Twelve new Uniones from Georgia; *I. Lea.*—Catalogue of Birds collected on the Rivers Camma and Ogobai, W. Africa, by Mr. P. B. Duchaillu, with notes and descriptions of new species; *J. Cassin.*—p. 177, On fresh-water shells, *I. Lea.*—Fossils from the Post-Pliocene of S. C., with Dr. Leidy's paper on the fossil Horse, and Prof. Agassiz' letter; *Holmes.*—p. 187, Four new exotic Unionidæ; *I. Lea.*—p. 188, Notes on American land-shells, No. 5; *W. G. Binney.*—p. 189, Catalogue of birds collected in the vicinity of Fort Tejon, Cal., with description of a new Syrnium; *J. Xantus.*—p. 194, Freyia Americana, a new animalcule from Newport Harbor; *J. Leidy.*—p. 195, Evorthodus, a new genus of Gobioids; *T. Gill.*—p. 196, Pimeletropis, a new genus of Siluroids from South America; *T. Gill.*—p. 197, New genera and species of N. American Tipulidæ with short palpi, with an attempt at a new classification of the tribe, (pp. 59 and three plates); *R. von Osten Sacken.*—p. 255, A spider catches a fish; *E. A. Spring.*—p. 256, Contributions to American Lepidopterology; *B. Clemens.*—p. 262, On a deformed fragmentary Human Skull from Jerusalem; *J. A. Meigs.* Supplement—Catalogue of the Invertebrate Fossils of the Cretaceous Formation of the United States; *W. M. Gabb.*

Journal Philadelphia Acad. Nat. Sci., Vol. VI, Pt. II.—Contains the following papers:—Synopsis of the North American Sphingidæ, by B. Clemens, M.D.; and New Unionidæ of the United States, by I. Lea, LL.D.

Canadian Naturalist and Geologist, Oct. 1859.—A new Gasterosteus, G. gymnetes; *Dawson.*—Glacial Phenomena of Canada and the North-eastern United States during the Drift Period; *Ramsey.*—On Ozone; *Smallwood.*—Fossils of the Calciferous Sandrock, etc.; *Billings.*—New Trilobites; *Billings.*—On the Aurora of 28th of August; *Smallwood.*

Annals and Magazine of Natural History, London, Oct. 1859.—Cellulose in starch-grains; *H. von Mohl.*—New spiders from Madeira; *J. Blackwall.*—Nudibranchiate mollusks of Ceylon; *Kelaart.*—New genera and species of phytophagous insects; *Baly.*—Digestive power in the Actiniæ; *Holdsworth.*—New Entomostraca from Jerusalem; two plates; *Baird.*—N. American Fungi; *Berkeley* and *Curtis.*—A new antelope (Kobus), from Central Africa; *Gray.*—Nov. 1859.—Reproduction of Bark-lice, with a plate; *R. Leuckart.*—New Anthribidæ; *Pascoe.*—Nomenclature of the Foraminifera; *Parker* and *Jones.*—Coleoptera of Old Calabar; *Murray.*—On certain genera of plants; *Miers.*—On Hydroid Zoophytes; *Allman.*—Ceylon insects; *F. Walker.*—A new Catharus from Western Mexico; *Sclater.*

Proceedings of the Zoological Society of London.—The volume for 1858 contains the following papers of more or less interest to American zoologists:—p. 38, Genera of Olivæ; *J. E. Gray.*—p. 90, On Stavelia, a new genus of Mytilidæ, and on some Distorted Bivalves, with a plate; *J. E. Gray.*—p. 92, Nerita and its operculum; *J. E. Gray.*—p. 145, Rearrangement of the genera of British Actiniadæ; *W. Thompson.*—On Sponges, by Dr. *Gray*, pages 113, 114, 229, and 531, with plates.—p. 136, Separation of the Salamandridæ into two families, by the form of the skull, *J. E. Gray.*—p. 225, Description of new Pinnæ; *S. Haniey.* (The South Carolinian Pinnæ called by American Conchologists P. seminuda and P. muricata are P. carolinensis, Hanl. and P. squamosissima, Phil.)—p. 339, Systematic Arrangement of the Tail-less Batrachians; *Gunther.*—p. 360, On the genus Synapta; *Woodward & Barrett.*—p. 373, Geographical Distribution of Reptiles; *Gunther.*—p. 413, Monograph of the Cæcidæ; *P. P. Carpenter.*—Also many papers relating to Central American Ornithology, by *P. L. Sclater.* W. S.

IV. ASTRONOMY AND METEOROLOGY.

1. *Discovery of the 57th planetoid* (*Mnemosyne*).—Another planet, appearing like a star of the 10th magnitude, supposed to be one of the group between Mars and Jupiter, was discovered by *M. Robert Luther*, Sept. 22, 1859, at the Observatory of Bilk. It is the 57th of the group, and has been named *Mnemosyne*.—(*Comptes Rendus*, Oct. 5, 1859.)

2. *Total Solar Eclipse of July* 18, 1860.—M. Faye has called the attention of astronomers and of all lovers of astronomy to the rare opportunity for important observations presented by this eclipse, which will traverse the earth from California to the Red Sea. The total darkness will travel across North America about the 60th degree of North latitude, leaving it at Hudson's Straits, and leaping the Atlantic, pass across Spain, strike the Balearic Isles, pass through Algeria, and crossing the Nile north of Dongola, take leave in Ethiopia. He names seven stations as specially favorable for observation, viz., 1. In Oregon between the Pacific ocean and the Rocky Mountains. 2. In Labrador, in lat. 59° N. 3 and 4. In Spain on the Atlantic and on the Mediterranean coasts. 5. At Ivica in the Balearic isles. 6. At Kabylia in Algeria. 7. At Dongola on the Nile.

At the time of the eclipse, Venus, Mercury, Jupiter and Saturn, will be in the vicinity of the Sun, and form a sort of rhomboid about it. Such a spectacle will not be visible again for many ages.

The objects to be secured by these observations may be arranged under four heads. 1. The more exact determination of the errors of the lunar tables. 2. The determination of the longitudes of places too remote from each other to be connected by the electric telegraph. 3. The verification of the present data for the solar and lunar parallax and the flattening of the earth. 4. The solution of certain questions respecting the physical constitution of the sun, and of the space in its vicinity.

M. Faye proposes that at the two principal stations photographic methods should be substituted in place of direct observation. A telescope of large object glass and long focus should be used, and a large number of proofs should be taken between the first and last contact, taking care to keep horizontal the collodionized plate. During the total obscuration, the whole object glass should be uncovered, and the most sensitive plates employed in order to obtain proofs on a large scale of the aureola and solar flames, while observers provided with hand telescopes, with fresh eyes, should deliberately study all particulars which photography can not secure.

As to the meteorological phenomena, M. Faye proposes to add the sympiezometer as more quick to show the rapid fluctuations of the atmosphere; and instead of the common thermometer to use a self-registering Breguet's metallic thermometer carried into the air by a captive balloon. The variations of the magnet should also be observed, for if the earth's magnetism is affected by the spots which periodically obscure part of the sun's disk, may it not be affected by the more rapid obscuration of the same by the moon? Possibly the wires of the electric telegraph, arranged now with and now against the direction of the eclipse may show perturbations too fugitive to be detected by bar magnets.

The station at Ivica seems to combine all the advantages offered by the peak of Teneriffe. Here especial attention should be given to the form and prolongations of the aureola, the nature and intensity of its light, and also to the zodiacal light, which is now made to play so important a part in the solar system. Careful search should also be made for the small planets near the sun, suspected by M. LeVerrier. Perhaps, moreover, it may be possible to notice clearly the motion of the cone of the lunar shadow, the lower base of which should traverse the surface of the sea at the rate of 900 metres per second, while the upper terminus, if visible, will show by its distance from the zenith the height of the upper strata of our atmosphere.

3. *Notice of the Meteor of Nov.* 15, 1859; by Prof. E. Loomis.—On the morning of Nov. 15th, about 9½ o'clock, a remarkable meteor was witnessed by a large number of persons in New York and its vicinity. The meteor was so brilliant that although the sun was unclouded and had an elevation of about twenty degrees above the horizon, the flash attracted the attention of well nigh every person who happened at that time to be looking nearly toward that part of the heavens. The apparent diameter of its head was somewhat less than that of the sun, and it had an appendage like the tail of a comet several degrees in length. Its apparent path was nearly vertical, with a slight inclination towards the west; and the length of its visible path was variously estimated from 15° to 25°. The entire period of its visibility did not exceed one or two seconds. No sound was heard at New York which could reasonably be ascribed to the meteor. By taking the mean of the estimates of several observers, I have determined that the point of the horizon where the meteor vanished was about 21° west of south.

From the newspaper reports we learn that the same meteor was seen at Salem, Boston, and New Bedford, Mass., at Providence, R. I., at New Haven, Middletown, and Waterbury, Conn., at Albany and many other places in New York, at numerous places in New Jersey, at Baltimore, Md., at Washington and Georgetown, D. C., as also at Alexandria and Fredericsburg, Va. At all of those places the meteor appears to have been seen at the same instant of absolute time; and at all the stations north of New York the appearance was almost identical, and the direction of the meteor was somewhat west of south.

From a newspaper notice coming from Prof. Henry of the Smithsonian Institution, we learn that at Washington the apparent path of the meteor was nearly perpendicular to the horizon, and its point of disappearance was estimated to be four degrees north of east. Those lines of direction as observed at New York and Washington intersect at a point a little north of Cape May; and inasmuch as at each of those stations the apparent path was nearly vertical, the actual path must also have been nearly vertical, and the meteor undoubtedly struck the earth at some point not very remote from Cape May.

This conclusion is confirmed by the reports of the meteor from New Jersey. The meteor was generally observed throughout the southern part of that State, and was everywhere succeeded by a very remarkable explosion. At Beeseley's Point, situated on the Atlantic Ocean near lat. 39° 20′, the course of the meteor is said to have been from northeast to

southwest. It was attended by a sudden flash of light, and left behind a curling track of a smoky or light cloudy appearance, which soon vanished. About a minute after the flash, there was heard a series of terrific explosions, which were compared to the discharge of a thousand cannon. These explosions continued for one or two minutes; they were very sharp and distinct, and shook the windows and doors of the houses. Similar noises have been reported from numerous stations in the southeastern part of New Jersey. These noises occasioned considerable alarm, and by some were thought to have been produced by an earthquake.

From the preceding facts it seems almost certain that the meteor must have struck the earth at some point a little north of Cape May; and as it was unquestionably a body of considerable size and of great density, if it struck on dry ground the meteor ought to have been discovered. As we have received no account of such a discovery there is reason to apprehend that the meteor may have descended into water, and probably into Delaware Bay. Analogy would lead us to conclude that this belonged to the class of iron meteors of which we have numerous specimens in our cabinets.

The velocity of this meteor was very extraordinary. It probably struck the earth at a distance of 110 miles from Washington, and is said to have been first seen at an elevation of 45°. This would make the length of its visible path 110 miles, and it is said to have described this path in two seconds, giving a velocity of 55 miles per second. A small portion of this velocity (7 miles per second) may be ascribed to the earth's attraction, and another portion was due to the motion of the earth in its orbit, for the earth was moving obliquely towards the meteor; but there still remains an independent velocity nearly double the velocity of the earth in its orbit. The path of the meteor in space could not therefore have been a circle with the sun for its center, as the above velocity is too great for any ellipse or even parabola; but such conclusions must be received with caution on account of the imperfection of the observations, for if we suppose the time of describing this path was three seconds, the independent velocity of the meteor would not have been much greater than that of the earth in its orbit.

4. *Meteoric Explosion, in West Tennessee, Sept. 1st*, 1859; by Prof. B. W. McDonnold, of Bethel College.—The first of September was made memorable by the great Aurora. Here, that day of the calendar had another *creta nota*—a meteoric explosion. This explosion was heard at Bethel College about 10 o'clock, A. M., and was at first thought to be the firing of cannon in honor of a political election.

The first report was double, like the almost simultaneous explosion of two great rockets, The reverberations were protracted, deep, distant. After the lapse of perhaps a half minute another explosion was heard, louder, deeper than the former, and the reverberations more protracted. The bearing of the sound was N. E.

I find that the report was heard forty miles north of us, where it was supposed to bear South East; it was heard twelve miles south and west, bearing same as here; but farther south and west it was not heard at all.

As yet, I have heard of no fragments of the meteor being found. I feel satisfied myself, however, of the meteoric origin of the explosion.

5. *Catalogue of the Meteorites in the Imperial Austrian Collection at Vienna;* by Prof. W. HAIDINGER.—Haidinger has communicated to the Austrian Academy of Sciences a complete list of the meteorites contained in the Imperial Collection at Vienna. It is an abstract from the complete catalogue made by the late Prof. Partsch and continued by Dr. Hoernes, the present director of the Imperial Cabinet.

In the list—which here follows—only the names of the localities and the time of falling (I) are given, or (II) in case of meteorites the time of falling of which is unknown they are classified according to the date when first described.

The letter *I* following the year indicates the specimens to be meteoric *iron.*

I. *Meteorites, with time of fall.*

	A. D.		
1.	1492,	Nov. 7,	*Ensisheim*, Alsace, Département du Haut-Rhin, France.
2.	1715,	April 11,	*Garz* (Schellin), near Stargard, Prussia.
3.	1751, *I.*	May 26,	*Agram* (Hraschina village), Croatia.
4.	1753,	July 3,	*Tabar* (Plan, Strkow), Bohemia.
5.	1753,	Sept. 7,	*Liponas*, near Pont de Verle and Bourg en Bresse, Dép. del'Ain, France.
6.	1768,	Sept. 13,	*Lucé* en Maine, Dép. de la Sarthe, France.
7.	1768,	Nov. 20,	*Mauerkirchen*, Inn, Lower Austria.
8.	1773,	Nov. 17,	*Sigena* (Sena village), Aragon, Spain.
9.	1785,	Feb. 19,	*Eichstaedt* (Wittens), Franconia, Bavaria.
10.	1787,	Oct. 13,	*Charkow* (Bobrik), Government Charkow, Russia.
11.	1790,	July 24,	*Barbotan* (Roquefort, Créon, Juillac, Mezin, Agen, &c.), Dép. des Landes, Dép. du Gers, Dép. du Lot et Garonne, formerly Gascony, France.
12.	1794,	June 16,	*Sienna*, Tuscany.
13.	1795,	Dec. 13,	*Wold Cottage*, Yorkshire, England.
14.	1798,	March 8–12,	*Salès*, near Villefranche, Dép. du Rhône, France.
15.	1798,	Dec. 13,	*Benares* (Krakhut village), Bengal, E. Indies.
16.	1803,	April 26,	*L'Aigle*, Normandy, Dép. de l'Orne, France.
17.	1803,	Oct. 8,	*Apt* (Saurette), Dép. de Vaucluse, France.
18.	1803.	Dec. 13,	*Maessing* (Dorf St. Nikolas), Eggenfeld, Bavaria.
19.	1804,	April 5,	*Glasgow* (High Possil), Scotland.
20.	1805,	March 25,	*Doroninsk*, Government Irkutsk, Siberia.
21.	1805,	June,	*Constantinople*, Turkey.
22.	1805,	Nov.,	*Asco*, Corsica.
23.	1806,	March 15,	*Alais*, St. Étienne de Solm and Valence. Dép. du Gard, France.
24.	1807,	March 13,	*Timochin*, (Timschino, according to Eichwald), Iuchnow, Gov. Smolensk, Russia.
25.	1807,	Dec. 14,	*Weston*, Connecticut.
26.	1808,	April 19,	*Parma* (Casignano, Borgo S. Donino).

27. 1808, May 22, *Stannern*, Iglau, Moravia.
28. 1808, Sept. 3, *Lissa*, Bunzlau, Bohemia.
29. 1809, ? *Kikina*, Wiasemsk, Gov. Smolensk, Russia.
30. 1810, Aug. *Tipperary* (Mooresfort), Ireland.
31. 1810, Nov. 22, *Charsonville*, near Orleans, Dép. du Loiret, France.
32. 1811, March 12, *Kuleschowka*, Gov. Poltawa, Russia.
33. 1811, July 8, *Berlanguillas*, near Burgos, Spain.
34. 1812, April 10, *Toulouse*, Dép. de la Haute-Garonne, France.
35. 1812, April 15, *Erxleben*, between Magdeburg and Helmstaedt, Prussia.
36. 1812, Aug. 5, *Chantonnay*, between Nantes and La Rochelle, Dép. de la Vendée, France.
37. 1813, Sept. 10, *Limerick* (Adair, Scagh, Brasky, Faha), Limerick County, Ireland.
38. 1813, Dec. 13, *Lontalax* (Lontalaks), Gov. Wiborg, Finland.
39. 1814, Feb. 15, *Bachmut*, Gov. Iekaterinoslaw, Russia.
40. 1814, Sept. 5, *Agen*, Dép. du Lot et Garonne, France.
41. 1815, Oct. 3, *Chassigny*, near Langres, Dép. de Haute-Marne, France.
42. 1818, April 10, *Zaborzika* (Saboryzy, Saboritz on the Slutsch), Volhynia, Russia.
43. 1818, June, *Seres*, Macedonia, Turkey.
44. 1818, Aug. 10, *Slobodka*, Iuchnow, Gov. Smolensk, Russia.
45. 1819, June 13, *Jonzac* (Barbézieux), Dép. de la Charente, France.
46. 1819, Oct. 13, *Politz*, near Gera, Duchy of Reuss.
47. 1820, July 12, *Lixna* (Liksen), Lasdany, Gov. Witebsk, Russia.
48. 1821, June 15, *Juvenas*, near Libonnez, Dép. de l'Ardèche, France.
49. 1822, Dec. 13, *Épinal* (la Baffe), Dép. des Vosges, France.
50. 1823, Aug. 7, *Nobleborough*, Maine.
51. 1824, Jan. 15, *Renazzo*, in Ferrara, Papal States.
52. 1824, Oct. 14, *Zebrak* (Praskoles), near Horzowitz, Beraun, Bohemia.
53. 1825, ? Government *Iekaterinoslaw*, Russia.
54. 1825, Feb. 10, *Nanjemoy*, Maryland.
55. 1825, Sept. 14, *Honolulu*, Sandwich Islands.
56. 1827, May 9, *Nashville* (Drake Creek), Tennessee.
57. 1827, Oct. 5, *Bialystok* (Kuasta or Kuasti village), Russian Poland.
58. 1828, June 4, *Richmond*, Virginia.
59. 1829, May 8, *Forsyth*, Monroe County, Georgia.
60. 1829, Sept. 9, *Krasnoi-Ugol*, Gov. Riesan, Russia.
61. 1831, July 18, *Vouillé*, near Poitiers, Dép. de la Vienne, France.
62. 1831, Sept. 9, *Wessely* (Dorf Znorow), Moravia.
63. 1833, Nov. 25, *Blansko*, Bruenn, Moravia.
64. 1833, Dec. 27, *Okniny* (Okaninah), Kremenetz District, Gov. Volhynien, Russia.

65. 1835, Nov. 13, *Simonod* (Samonot), Belmont, Dép. de l'Ain, France.
66. 1836, Nov. 11, *Macao*, Prov. Rio Grande de Norte, Brazil.
67. 1837, July 24, *Gross-Divina*, near Budetin, Hungary.
68. 1837, Aug. *Esnaude*, Dép. de la Charente, France.
69. 1838, June 6, *Chandakapoor*, Berar, E. Indies.
70. 1838, Oct. 13, *Capeland* (Bokkeveld, 15 miles from Tulpagh), South Africa.
71. 1839, Feb. 13, *Little Piney*, west of Potosi, Missouri, lat. 37° 55′ N., long. 92° 5′ W. from Greenwich.
72. 1840, July 17, *Cereseto*, near Offiglia, Casale, Piedmont.
73. 1841, March 22, *Grueneberg* (Heinrichsau), Prussian Silesia.
74. 1841, June 12, *Château-Renard*, S. E. of Montargis, Dép. du Loiret, France.
75. 1842, April 26, *Milena* (Milyan), Pusinsko Selo, 4½ miles S. of Milena, Croatia.
76. 1842, June 4, *Aumières*, Canton St. George, Dép. de la Lozère, France.
77. 1843, March, *Bishopville*, South Carolina.
78. 1843, June 2, *Utrecht*, Blaauw Kapel, Loewenhutye, Netherlands.
79. 1843, Sept. 16, *Klein-Wenden*, near Nordhausen, Prussia.
80. 1846, May 8, *Macerata*, Monte Milan village, Ancona, Papal States.
81. 1847, Feb. 25, *Iowa*, Linn County, Iowa.
82. 1847, *I.* July 14, *Braunau* (Hauptmannsdorf), Koeniggraetz, Bohemia.
83. 1849, Oct. 31, *Cabarras County*, North Carolina.
84. 1851, April 17, *Guetersloh*, Westphalia.
85. 1852, Sept. 4, *Mezö-Madaras* (and Fekete), Transylvania.
86. 1852, Oct. 13, *Borkut*, Marmaros, Hungary.
87. 1853, Feb. 10, *Girgenti*, Sicily.
88. 1855, May 13, *Bremervoerde*, Landdrostei Stade, Hanover.
89. 1857, Oct. 10, *Ohaba*, E. of Karlsburg, Transylvania.
90. 1857, Apr. 15, *Kaba*, S. W. of Debreczin, Nordbihar, Hungary.
91. 1858, May 19, *Kakova*, N. W. of Oravitza, Temesvar Banat.

II. *Meteorites, with time of discovery.*

92. 1751, *I.* *Steinbach*, between Eibenstock and Johann-Georgenstadt, Saxony (sometimes given as coming from Norway, Tabor, Senegal, &c.).
93. 1763, *I.* *Senegal*, Siratik in Bambuk, Africa.
94. 1776, *I.* *Krasnojarsk*, Gov. Ieniseisk, Siberia.
95. 1784, *I.* *Toluca*, Mexico.
96. 1788, *I.* *Tucuman* (Otumpa), Argentine Republic, S. America.
97. 1792, *I.* *Zacatecas*, Mexico.
98. 1801, *I.* *Cape of Good Hope*, Africa.
99. 1811, *I.* *Elbogen*, Bohemia.

100. 1811, *I.* *Durango*, Mexico.
101. 1814, *I.* *Bitburg*, Lower Rhine, Prussia.
102. 1814, *I.* *Texas* (Red River).
103. 1815, *I.* *Lénarto*, Scharosch, Hungary.
104. 1816, *I.* *Bahia* (Bemdego), Brazil.
105. 1819, *I.* *Baffins Bay*, Greenland.
106. 1822, *I.* *Brahin*, Gov. Minsk, Russia.
107. 1823, *I.* *Rasgata*, New Granada, S. America.
108. 1827, *I.* *Atacama*, Bolivia.
109. 1828, *I.* *Caille* (Grasse), Dép. du Var, France.
110. 1829, *I.* *Bohumilitz*, Prachin, Bohemia.
111. 1830, *I.* *Guilford*, North Carolina.
112. 1838, *I.* *Claiborne*, Alabama.
113. 1839, *I.* *Asherville*, Buncombe Co., North Carolina.
114. 1840, *I.* *Smith County*, Coney Fork, Tennessee.
115. 1840, *I.* *Cocke County*, Cosby-Creek, (also called Sevier iron), Tennessee.
116. 1841, *I.* *Petropaulowsk*, Gov. Tomsk, Siberia.
117. 1843, *I.* *Oaxaca*, Mexico.
118. 1844, *I.* *Burlington*, Otsego Co., New York.
119. 1844, *I.* *Arva* (Szlanicza), Hungary.
120. 1845, *I.* *Lockport*, New York.
121. 1845, *I.* *Green County* (Babbs-Mills), Greenville, Tennessee.
122. 1845, *I.* *Government Simbirsk*, Russia.
123. 1845, *I.* *Government Kursk*, Russia.
124. 1845, *I.* *Government Poltawa* (according to Eichwald in the district of Kamensk), Russia.
125. 1847, *I.* *Seeläsgen*, Neumark, Brandenburg, Prussia.
126. 1849, *I.* *Chesterville*, South Carolina.
127. 1850, *I.* *Schwetz*, Province of Prussia.
128. 1850, *I.* *Ruff's Mountain*, Newberry, South Carolina.
129. 1850, *I.* *Salt River*, Kentucky.
130. 1851, *I.* *Seneca Falls*, Cayuga Co., New York.
131. 1852, *Mayence*, Duchy of Hesse.
132. 1853, *I.* *Union County*, Georgia.
133. 1853, *I.* *Lion River*, Namaqua Land, South Africa.
134. 1854, *I.* *Tazewell*, Claiborne Co., Tennessee.
135. 1854, *I.* *Putnam County*, Georgia.
136. 1854, *I.* *Canada*, Madoc, Canada West.
137. 1856, *Hainholz*, S. W. of Paderborn, Minden, Westphalia.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Inquiries into the Phenomena of Respiration;* by EDWARD SMITH, M.D., (L. E. and D. Phil. Mag., xvii, 439).—The author gives in this communication the result of numerous inquiries into the quantity of carbonic acid expired, and of air inspired, with the rate of pulsation and respiration,—1st, in the whole of the twenty-four hours, with and without exertion and food; 2nd, the variations from day to day, and from season to season; and 3rd, the influence of some kinds of exertion.

After a description of the apparatus employed by previous observers, he describes his own apparatus and method. This consists of a spirometer to measure the air inspired, capable of registering any number of cubic inches; and an analytical apparatus to abstract the carbonic acid and vapor from the expired air. The former is a small dry gas-meter, of improved manufacture, and the latter consists of—1st, a desiccator of sulphuric acid to absorb the vapor; 2nd, a gutta-percha box, with chambers and cells, containing caustic potash, and offering a superfices of 700 inches, over which the expired air is passed, and by which the carbonic acid is abstracted; and 3rd, a second desiccator to retain the vapor which the expired air had carried off from the potash box. A small mask is worn, so as to prevent any air entering the lungs without first passing through the spirometer, and the increase in the weight of this with the connecting tube and the first desiccator gives the amount of vapor exhaled, whilst the addition to the weight of the potash box and the second dessiccator gives the weight of the carbonic acid expired. The balances employed weigh to the $\frac{1}{1000}$ of a grain, with 7 lbs. in the pan. By this apparatus the whole of the carbonic acid was abstracted during the act of expiration, and the experiment could be repeated every few minutes, or continued for any number of hours, and be made whilst sleeping and with certain kinds of exertion.

The amount of carbonic acid expired in the twenty-four hours was determined by several sets of experiments. Four of these, consisting of eight experiments, were made upon four gentlemen, on the author, Professor Frankland, F.R.S., Dr. Murie, and Mr. Moul, during the eighteen hours of the working day. In two of them, the whole of the carbonic acid was collected, and in two others the experiment was made during ten minutes at the commencement of each hour, and of each hour after the meals. The quantity of carbonic acid varied from an average of 24·274 oz. in the author to 16·43 oz. in Professor Frankland. The quantity evolved in light sleep was 4·88 and 4·99 grains per minute, and scarcely awake 5·7, 5·94, and 6·1 grains at different times of the night. The author estimates the amount in profound sleep at 4·5 grains per minute; and the whole evolved in the six hours of the night at 1950 grains. Hence the total quantity of carbon evolved in the twenty-four hours, at rest, was, in the author, 7·144 oz. The effect of walking at various speeds is then given, with an estimate of the amount of exertion made by different classes of the community, and of the carbon which would be evolved with that exertion.

The author then states the quantity of air inspired in the working day, which varied from 583 cub. in. per minute in himself to 365 cub. in. per minute in Professor Frankland; the rate of respiration, which varied in different seasons as well as in different persons; the depth of inspiration, from 30 cub. in. to 39·5 cub. in.; and the rate of pulsation. The respirations were to the pulsations as 1 to 4·63 in the youngest, and as 1 to 5·72 in the oldest. One-half of the product of the respirations into the pulsations gave nearly the number of cubic inches of air inspired in some of the persons, and the proportion of the carbonic acid to the air inspired varied from as 1 gr. to 54·7 cub. in. to as 1 gr. to 58 cub. in. The variations in the carbonic acid evolved in the working day gave an average

maximum of 10·43, and minimum of 6·74 grains per minute. The quantity increased after a meal and decreased from each meal, so that the minima were nearly the same, and the maxima were the greatest after breakfast and tea.

The effect of a fast of forty hours, with only a breakfast meal, was to reduce the amount of carbonic acid to 75 per cent. of that which was found with food; to render the quantity nearly uniform throughout the day, with a little increase at the hours when food had usually been taken, and to cause the secretions to become alkaline.*

The variations from day to day were shown to be connected with the relation of waste and supply on the previous day and night, so that with good health, good night's rest, and sufficient food, the amount of respiration was considerable on the following morning, whilst the reverse occurred with the contrary conditions. Hence the quantities were usually large on the Monday. Temperature was an ever-acting cause of variation and caused a dimunition in the carbonic acid as the temperature rose.

The effect of season was to cause a diminution of all the respiratory phenomena as the hot season advanced. The maximum state was in spring, and the minimum at the end of summer, with periods of decrease in June and of increase in October. The diminution in the author was 30 per cent. in the quantity of air, 32 per cent. in the rate of respiration, and 17 per cent. in the carbonic acid. The influence of temperature was considered in relation to season, and it was shown that whilst sudden changes of temperature cause immediate variation in the quantity of carbonic acid, a medium degree of temperature, as of 60°, is accompanied by all the variations in the quantity of carbonic acid, and that there is no relation between any given temperature and quantity of carbonic acid at different seasons. Whatever was the degree of temperature, the quantity of carbonic acid, and all other phenomena of respiration, fell from the beginning of June to the beginning of September. The author then described the influence of atmospheric pressure, and stated that neither temperature nor atmospheric pressure accounts for the seasonal changes.

The kinds of exertion which had been investigated were walking and the treadwheel. Walking at two miles per hour induced an exhalation of 18·1 grs. of carbonic acid per minute, and at three miles per hour of 25·83 grs.; whilst the effect of the treadwheel at Coldbath Fields Prison was to increase the quantity to 48 grs. per minute. All these quantities vary with the season, and hence the author recommends the adoption of relative quantities, the comparison being with the state of the system at rest, and apart from the influence of food.

2. *Dr. Newberry's Explorations in New Mexico, Utah and Texas*, during the past season, are rewarded by many new and important discoveries, especially in structual geology and palæontology. His collection of fossils is very large, offering conclusive evidence of the geological structure of a very large area. Of the cretaceous deposits he was fortunate in obtaining a particularly satisfactory analysis. Contrary to all our previous notions, these beds turn out to be much more largely developed—that is, existing in much greater force, stratigraphically, West of

* The quantity of air was reduced 30 per cent, that of vapor in the expired air 50 per cent, the rate of respiration was reduced 7 per cent, and of pulsation 6 per cent.

the Rocky Mountains, than East of them. In Southern Utah, (just where Marcou claims there are no cretaceous rocks) he found beautiful exposures of 4000 feet thickness of strata of that age, with abundant fossils, both animal and vegetable. The bones of a huge Saurian are among Dr. Newberry's novelties.

We hope in our next Number to be able to give a more exact statement of Dr. Newberry's important discoveries.

Rumors reach us of other and even more startling geological discoveries in the extreme West and North, which we are not at liberty to name at present, but which ere long will be announced, from the proper authority.

3. *Discovery of Devonian rocks and fossils in Wisconsin.* (Private communication to the editors.)—At a late meeting of the Milwaukee Geological Club or Association, Mr. I. A. Lapham announced the discovery of rocks near Milwaukee, equivalent to the Devonian (Old Red Sandstone,) containing remains, which he exhibited, of characteristic fishes. These remains consist of fragments of bone, teeth, a paddle with portions of the tuberculated skin or osseous covering. The bed containing these remains overlies the Niagara group, and is the uppermost of the geological series yet observed in Wisconsin.

4. *Cretaceous Strata at Gay Head, Mass.*—Wm. Stimpson, Esq., accompanied by Messrs. Slack and Ordway, during an excursion in August to Martha's Vineyard, obtained at Gay Head many new fossils in addition to those mentioned by Hitchcock, an examination of which appears to authorize the conclusion that these well known beds are Cretaceous rather than Eocene. Among the fossils obtained are cretaceous bones, vertebræ and teeth of shark, (fragments of some teeth indicating a length of seven inches!) some brachyurous crustacea in a good state of preservation, twelve species of bivalve mollusca, and one univalve; also leaves, fragments and seeds of dicotyledonous plants, &c.

5. *The New Museum of Comparative Zoology, at Cambridge*, is making rapid progress. One wing is nearly ready to receive collections. During his summer trip in Europe, Agassiz made large and important acquisitions for the Museum, in addition to the vast stores already awaiting an occasion for display. Besides a superb suit of fossil Crustacea, Agassiz was so fortunate as to purchase at Heidleburg the collection of fossils from which Broun's *Lethaea geognostica* was composed. This collection contains the original specimens of the first and most important writers on Palæontology.

Another important addition to the new museum has been made by a sea Captain, who has just brought from Penang and Singapore some three thousand specimens of fish, crustacea, and a most beautiful and choice collection of zoophytes.

6. William P. Blake, Esq., the geologist, has assumed the editorship of the Mining Magazine, a monthly heretofore published in New York. Under his direction this Journal will undoubtedly become a reliable exponent of the important interests it represents.

7. Prof. Wm. S. Chauvenet, lately of the U. S. Naval Academy, at Annapolis, has accepted the Chair of Mathematics in the University of Missouri, at St. Louis.

8. Professor DANA was, by our last dates (Nov. 26th) at Florence, on his way to Rome—designing to divide the winter and spring between Rome, Naples and Sicily, if the state of the country permits his visiting that Island. His health was improving.

NEW BOOKS.—

1. *Archaia; or Studies of the Cosmogony and Natural History of the Hebrew Scriptures;* by J. W. DAWSON, LL.D., F.G.S., author of "*Acadian Geology*," Principal of McGill College. Montreal: B. Dawson & Son. London: Sampson, Low, Son & Co. 1860. 12mo, pp. 400.—The author of this interesting volume brings to his task the union of a varied scientific, literary and biblical acquirement with a hearty Christian faith. Like all devout and earnest men of science he has an unwavering confidence in the divine unity of truth, and does not for a moment doubt that the genesis of the rocks will confirm the genesis of Moses. He seizes boldly and with candor the real difficulties which every writer has found standing in his way when treating this interesting problem. After an eloquent introduction and a discussion of the object, character and authority of the Hebrew Cosmogony, of the general views of nature contained in the Hebrew Scriptures, &c., he thus sums up his chapter on the Days of Creation—the events of the first day. "At the beginning of the period, the earth, covered with a universal ocean and misty atmospheric mantle, was involved in perfect darkness. A luminous ether was called into existence, which spread a diffused light throughout the whole solar system. This luminous matter being gradually concentrated toward the centre of the system at length produced, in connection with the earth's rotation, the alternation of day and night. These changes were the work of a long period—an æon or day of the Creator."

Undoubtedly the most difficult points in the whole Mosaic Cosmogony, to explain in a rational manner consistent with the views of science, are the creation of plants before the appearance of the '*luminaries*,' and the separation of the two organic kingdoms by the introduction of this middle term. These difficult points are treated with much acuteness and learning, and with a full recognition of the various opinions put forth to meet them by various authors. If we cannot fully agree with our Author in his conclusions, we can truly say that no one has higher claims to a respectful hearing, and if the conclusions at which he arrives leave yet something to be desired, the want rests more in the imperfection of our knowledge than in Prof. Dawson's enunciation of it.

Prof. Dawson does not shrink from a fearless review of the much vexed question of the unity of the human race in a long and interesting chapter on the "Unity and Antiquity of Man." It is hardly necessary to add that he adopts the Mosaic view. We can do this volume little justice, in these few lines to which our last pages restrict us, but we can earnestly commend its spirit, and hope for its wide perusal by all who follow the course of the deep questions it involves.

2. *On the Origin of Species by means of Natural Selection: or, the Preservation of Favored Races in the Struggle for Life;* by CHARLES DARWIN. (Murray.)—[Waiting the arrival of our copy of this new volume from Mr. Darwin's pen, which at this present writing (Dec. 16) has not reached the United States, we copy some passages from a rather

timid and superficial notice of the work in the London Athenæum of Nov. 19th. It is no doubt destined to produce a great discussion on what may properly be called the most fundamental truth of natural history.—Eds.]

"Naturalists of the highest eminence are thoroughly satisfied that each species of animal—all that flies, and walks, and creeps, and wades—has been independently created; and the majority of naturalists have agreed with Linnæus in supposing that all the individuals propagated from one stock have certain distinguishing characters in common, which will never vary, and which have remained the same since the creation of each species. Mr. Darwin, on the contrary, believes that 'the innumerable species, genera, and families of organic beings with which this world is peopled, have all descended, each within its own class or group, from common parents, and have all been *modified in the course of descent*.' To his mind, 'it accords better with what we know of the laws impressed on matter by the Creator that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of the individual.' When he views 'all beings not as special creations, but as the lineal descendents of some few beings which lived long before the first bed of the Silurian system was deposited, they seem to him to become ennobled.' We confess some doubt and some uneasiness here. 'Judging from the past, we may safely infer that not one living species will transmit its unaltered likeness to a distant futurity. And of the species now living very few will transmit progeny of any kind to a far distant futurity; for the manner in which all organic beings are grouped shows that the greater number of species of each genus, and all the species of many genera, have left no descendants, but have become utterly extinct. We can so far take a prophetic glance into futurity as to foretell that it will be the common and widely-spread species, belonging to the larger and dominant groups, which will ultimately prevail and procreate new and dominant species.' We cannot say that this is easy doctrine.

"To support these bold views the volume is devoted. The world of animals is contemplated as engaged in one vast unceasing struggle for existence. All organic beings are exposed to severe competition. The face of Nature, it is true, is bright with gladness, and her garner-houses are stored with an abundance of food. Birds sing, insects hum, beasts prowl about in ease and take no thought for the morrow: but the morrow measured by seasons and years has not always a superabundance of food for them. The struggle for existence does not merely relate to self, but includes success in leaving healthy progeny. The high rate at which all organic beings tend to multiply approaches to the rapidity of geometrical increase. More individuals are produced than can by any possibility be supported. There must, then, in every case, be a severe struggle, either of one individual with another of the same species, or with individuals of distinct species, or with the physical conditions of life."

"Now, how does the struggle for existence operate with respect to Variation? Man can produce varieties in animals by the practice of selection. What he has already done by this means the menagerie, the poultry-yard, the field, and the garden display. Is there anything analo-

gous to this in the course of Nature? The author contends that there is, and he names it *Natural Selection*. This principle, whatever others may think of it, and whether they admit its operations or not, in Mr. Darwin's book plays the prominent part. It may be plainly defined, and appears to be briefly this. Under domestication it may be truly said that the whole animal organization becomes in some degree plastic. As variations useful to man have undoubtedly occurred, is it not to be expected that other variations, useful in some way to each being in the great and complex battle of life, should sometimes occur in the course of thousands of generations? If such do occur, then, remembering the struggle for existence, individuals possessing any advantage over others would have the best chance of surviving and of procreating their kind, while injurious variations would be rigidly destroyed. Such a continual preservation of favorable, and rejection of injurious variations, is the principle of Natural Selection. It is illustrated, amplified and confirmed by abundant examples through many pages."

"Certainly there is something poetical in the conception of a succession of created beings, daily and hourly making the wisest election amidst all variations and divergencies; carefully rejecting what is bad, and preserving and accumulating all that is good; operating silently and insensibly, whenever and wherever opportunity offers, towards the improvement of every organized existence in relation to its organic and inorganic condition of life. There is, too, a certain simplicity in the theory of descent with modification through natural selection from a few vastly remote progenitors. 'I believe,' says Mr. Darwin, 'that animals have descended from at most only four or five progenitors, and plants from an equal or lesser number. Analogy would lead us one step further—namely, to the belief that all animals and plants have descended from some one prototype.' A cabbage may have been the parent plant, a fish the parent animal.

"A man of imaginative power might most attractively depict the grand yet simple and direct issues of such a theory. Here are a vast variety of forms of life, most wonderfully co-adapted, most closely connected, most richly adorned, yet they are all 'the lineal descendants of those which lived before the Silurian epoch; and one may feel certain that the ordinary succession by generation has never once been broken, and that no cataclysm has desolated the whole world. Hence, we may look with some confidence to a secure future of equally inappreciable length. And as Natural Selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress toward perfection.' Yes, an unbroken, sure, though slow, living progress towards animal perfectibility is a delightful vision; natural and gradual optimism is a welcome fancy. What need of distinct creation? If a monkey has become a man—what may not a man become?

"Let the past history of organic life speak. From the thirteen miles in thickness of British strata (exclusive of igneous rocks) comes there no testimony? Palæontology is summoned into court, and is closely interrogated by Mr. Darwin. This proves but a hesitating and reluctant witness; yet counsel for the new theory detects and exposes its imperfections where its testimony is not favorable. We might fairly expect to find in

the fossiliferous rocks not a few proofs of the former existence of the numerous intermediate links between distinct specific forms if the proposed theory be true. We do not find them, many will allege, because they never existed. Not so, says our theorist,—but because they were never preserved. Palæontology, however, has not yet revealed any such finely graduated organic scale, and it is not logical to assume that it ever will. When a record is flatly against you, it is quite allowable for you to display its imperfection, but, that being proved, you have only established a negative, and have acquired no confirmation. Grant imperfection, enormous lapse of time, poverty of palæontological collections, and comparative restriction of research, and other such postulates, and then the theory stands just as it stood before, uncorroborated by geology.

"There is positively hostile testimony from the rocks to be confronted. Whole groups of species suddenly and abruptly appear in certain formations, and seem at once to contradict any theory of transmutation of species. Either that fact or the theory must be overturned. Of course, Mr. Darwin accepts the former alternative, and strives to show how liable we are to error in supposing that whole groups of species have been suddenly produced. But another and an allied objection may be started, derived from the manner in which numbers of species of the same group suddenly appear in the lowest known fossiliferous rocks. To meet this and uphold the new theory, it must be sustained by another, viz.,—that before the lowest Silurian stratum was deposited, immensely protracted periods elapsed, at least as long as any subsequent periods, and that during these vast extensions of time the world swarmed with living creatures. Several of the most eminent geologists, including Murchison, will refuse to admit this presumption. Mr. Darwin's geology is more singular than we had thought. 'For instance,' says he, 'I cannot doubt that all Silurian trilobites have descended from some one crustacean which must have lived long before the Silurian age, and which probably differed greatly from any known animal.' Extend and multiply such assumptions, and the theories may take any form you please."

"After all, this book is but an abstract. The larger work is nearly finished, but it will demand two or three more years for completion. Health, labor, and observations are wanting for awhile, but in due season we hope to see the work 'with references and authorities for the several statements.' We should offer remarks on some important topics but that our author says, 'A fair result can be obtained only by fully stating and balancing the facts and arguments on both sides of the question; and this cannot possibly be here done.'

"Meanwhile Mr. Darwin anticipates small favor from many of the older and more eminent naturalists; his hopes chiefly rest on the young, and, as he would say, the unshackled. 'A few naturalists,' he observes, 'endowed with much flexibility of mind, who have already begun to doubt on the immutability of species, may be influenced by this volume; but I look with confidence to the future, to young and rising naturalists who will be able to view both sides of the question with impartiality.' It is enough for us to add that neither book, author, nor

subject is of merely ordinary character. The work deserves attention, and will, we have no doubt, meet with it. Scientific naturalists will take up the author upon his own peculiar ground; and there will we imagine be a severe struggle for at least theoretical existence."

3. *Elements of Somatology: A Treatise on the general properties of Matter;* by GEO. M. MACLEAN, M.D., Prof. Chemistry and Nat. Philosophy, in Alleghany City, Pa. New York: J. Wiley, 56 Walker St., 1859. 12mo, pp. 124.—This modest little volume, the author tells us in his preface, is the fruit of many hours of study during a period of ill-health—a sort of "Consolations of a Philosopher."

It is a simple exposition of accepted doctrines on the familiar subjects of extension, impenetrability, figure, divisibility, indestructibility, porosity, compressibility, dilatibility, mobility, inertia, contraction, repulsion, polarity, elasticity, and the constitution of matter. The subject of Attraction he considers under thirty-one subdivisions. His expositions of the phenomena of adhesion, capillarity and osmose are more full and satisfactory than it is usual to find in elementary works. On many points in his discussions, we might join issue with our Author, as when he states cohesive attraction to be only a modification of gravitation—(p. 57)—and when he adduces the phenomena of contraction in a soap-bubble, in illustration of the cause of the meniscus of capillarity (p. 69).

It would have added materially to the value of the Treatise, and its interest to the student and general reader, if the author had appended to passages marked as quotations a reference to the authority from which they are copied. Except a quotation accredited to Cavallo, we do not recall a single reference to any authority in the volume.

A brief statement of the accepted doctrines of physics on the subject of "*Molecular Forces*" would have relieved his chapters on attraction and repulsion of several obscure points.

The work bears marks of haste, or want of careful revision of the press. Among many examples of this we may name the sentence under capillary attraction, commencing "The tube having the form of a syphon," (foot of p. 69) which conveys so confused a notion of what the Author seeks to express, that after several readings we have been unable to comprehend it. Bodies are said to weigh *less* near the poles than at the equator, (p. 55), and numerous typographical blemishes evidence the disadvantage of printing a scientific book at a distance from the press. These minor faults are easily removed in a new edition—which will be very likely to be called for, as the book is one of convenient reference for all teachers. The author will, however, confer a great favor on all such readers in a new edition, by quoting his authorities.

4. *The Telegraphic Manual, a complete history and description of the Semaphoric, Electric and Magnetic Telegraphs of Europe, Asia, Africa, and America, ancient and modern, with 625 illustrations;* by T. P. SCHAFFNER, of Kentucky. N. York, 1859. 8vo, pp. 850.—The title of this volume is an index to its contents. That he may leave nothing behind him for future explorers, the author commences his labors with Adam and Eve, in Eden! Mr. Schaffner has, from his wide and long experience in telegraphic construction and management both in the United States and in Europe, remarkable qualifications for the work he has under-

taken. The result of his labors is satisfactory. His work, in fullness of detail, leaves little to desire, and he appears always solicitous to avoid the charge of partizanship in awarding to rival parties what he judges to be their respective shares of merit, in cases of contested claims. As a literary production, it is to be regretted that the author did not submit his manuscripts to the revision of some judicious literary friend—thus avoiding certain faults of style of too frequent occurrence. But these are minor faults and can be easily pardoned where there is so much to praise.

5. *Bail's Drawing System:* The Human Head, by Louis Bail, (graduate of the Royal Academy of Fine Arts, in Munich). New Haven: Author, 1859. 8vo, 64 plates in outline.—Prof. Bail has here done a great service to both teachers and pupils in the Arts in the United States. The success which has followed the Author's use of his own system in many of our higher seminaries, as well as in public classes, is the best guaranty of the adaptation of its parts to the great ends of instruction, and no doubt will secure its general adoption.

6. *Memoir of John Griscom, LL.D., late Professor of Chemistry and Nat. Philosophy, &c.;* by his son, John H. Griscom, M.D. New York: Carter, 1859. 8vo, pp. 427.—Some among the older readers of this Journal will recall with pleasure the selections from foreign scientific literature, which for many years Prof. Griscom prepared for these pages. His active life was well filled with varied duty as an instructor and philanthropist. He was either largely or entirely instrumental in the establishment of the New York High School; the Society for the prevention of Pauperism; the House of Refuge; and other institutions of public charity, which amid all the complaints of profligacy in her public administration, have shed a peculiar honor on the active benevolence of the City of New York.

As early as 1818, he instituted and sustained for many years, independent courses of scientific lectures, in New York city, and in other places—illustrating his courses by numerous experiments, and a costly apparatus procured at his own expense. This was long before the era of *popular lectures*, and Dr. Griscom, with the senior Editor of this Journal, may claim the honor of inaugurating a system which has since become almost universal in the United States.

Dr. Griscom published two volumes of Travels in Europe, in 1818–19, remarkable for the spirit of candor and kindness which is seen on every page, and interesting to this day, for the characteristic personal sketches he gives of the distinguished men of science he met abroad.

Dr. Griscom was an eminently good man; a member of the Society of Friends; a devout Christain believer, and without bigotry. His mild and gentle nature delighted in the most catholic liberality, and many of his warmest friends were members of other Christian sects. We have recently been called upon to commemorate several eminent scientific friends and collaborators—Cleaveland, Hare, Redfield and Olmsted, now numbered with the dead. We now add the name of Griscom—a name cherished long and warmly by intimate social and scientific relations. Our early auxiliaries and friends in science are now few in number, and our duties are soon to pass into younger and we hope better hands—

but the pioneers will be remembered as the pilgrims of science, although its votaries are now a Legion. This Memoir is a fine example of its class, and does credit both to the filial piety and literary ability of its distinguished Author. B. S.

FLEURY: *Des races qui se partagent l'Europe.* 8vo, 132 pages. Hachette & Co.—This author has brought to his study of the races great learning and a deep knowledge of the facts. He considers modern European civilization as springing from the German race.

JAMIN: *Cour de Physique de l'Ecole polytechnique.* T. II. with 3 plates and 191 figures in the text.—This volume contains *Heat* and *Acoustics*. The plates are engraved and the mathematical formulæ are printed with the neatness and accuracy which distinguish at present the productions of the press of Bachelier above all others in France.

G. LAMÉ: *Leçons sur les coordonnées, curvilignes et leurs diverses applications*, in 8vo. 1859. Mallet-Bachelier, Paris.—Under this title the distinguished Professor of the Polytechnic School introduces to us a new branch of methematical science. It is geometry considered from a physico-mathematical point of view.

OBITUARY.—

Professor WILLIAM W. TURNER, one of our most distinguished philologists, died at Washington, Nov. 29, 1859, in the 50th year of his age. Although an excellent linguist, he devoted himself less to the study of words than to that of the structure of languages, their origin and connections, upon which subject his views were eminently philosophic. He was born in London, but was brought in his fifth year to this country, where he has ever since resided. He early developed a taste for the study of oriental languages and was in 1842 appointed instructor in the Hebrew and cognate tongues in the Union Theological Seminary of New York. The last seven years of his life were spent in Washington, where his attainments and upright, amiable deportment secured to him a host of friends. He did a vast amount of work in the way of translation and grammatic compilation, little of which has, however, appeared in his name:—he is chiefly known for his contributions to the "Bibliotheca Sacra" and to the journals of the American Oriental and Ethnological societies. But his published works give no adequate idea of the extent of his labors; his stores of knowledge were always open to his friends and most freely imparted, thus contributing to the advancement of sciences other than his own. He had, during the past ten years, given much attention to the study of the Aborigines of North America and their languages, not only elaborating general principles from the vocabularies collected by travellers, but confirming these and adding new information by communication with the delegates from various tribes that visited Washington upon business with the central government. In this investigation he accumulated a large amount of materials which will, it may be hoped, be some time given to the world. W. S.

Dr. GEORGE WILSON, First Regius Professor of Technology in the University of Edinburgh, and Director of the Industrial Museum of that City, died near the end of November last, at the early age of 41. He was the biographer of Reid and Cavendish, and author of numerous researches, among which are the discovery of fluorine in blood and sea-water. Other of his published works are his "Researches on Color-blindness," an "Elementary Treatise on Chemistry," and "The Five Gate-ways of Knowledge." He is a great loss to his native city and the world.